CURIOSITY AND COMMERCIALIZATION: FACULTY PERSPECTIVES ON SPONSORED RESEARCH, ACADEMIC SCIENCE AND RESEARCH AGENDAS

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Education)
in The University of Michigan
2009

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DEDICATION

Obtaining a Ph.D. is an onerously selfish endeavor. The commitment of time, mental and physical energy, and opportunity costs to make the quest possible are enormous, and the sacrifices only become more real as the work expands. It is strange how time seems to zip by yet stand still simultaneously, as the world carries on while the life of the graduate student becomes defined as the work of the graduate student. Life can seem on hold while others around you live outside the bubble that makes you forget the amount of time elapsed.

It is the time lost and the friends who have drifted away that I regret the most. I hope I can atone by reconnecting and reinvesting in the personal relationships that were made to suffer as I organized my life around achieving this degree.

To my wife, immediate family, and friends—near, far, and distant—I thank you for your endless patience and request your infinite understanding. Thus, I dedicate the completion of this dissertation and degree to our continued relationships, and the time hereafter to make up for all that was put on hold.

ACKNOWLEDGEMENTS

The number of people who have made the attainment of this degree possible is in many ways unknowable, as all the life experiences I had before and during this process led to the perspectives I have, and the ability I developed to start, persist in, and eventually complete the work. Still, many people must be thanked and acknowledged for what they meant to me and my ability to reach this point.

To my wife Anne: no one could have been more understanding and accepting of me, my fits and starts, my doubts and fears, and the slow development of my identity as a graduate student. Thus, I thank her for her love and patience, and her willingness to be here while our lives were on hold in many ways. I know I owe you many vacations, much rest, and the opportunity to pursue your own interests for a change.

To my family—Mom, Dad, Joe: I recognize that the actual details of what I have been doing all this time were unclear, and my explanations insufficient, so I thank you for being understanding even though I know I didn't talk to you all that much about my work. I always knew you were interested in my achievements and were happy for me to find my own way.

I would like to publicly express thanks to two long-time friends who have served as models of scholarship for me and continue to help me shape my path in academia. My hometown friend Rick Cline, who once offered the philosophy that "the only reason to start a Ph.D. is to finish a Ph.D.," has provided encouragement while always displaying the kind of intellectual curiosity that inspires me to emulate him. Also, Tim Cain, whom I have known since our OSU days, is an inspiration to me as he exudes the easy grace in his research and analysis that all scholars need.

I would also like to thank the faculty in CSHPE who have taught me and contributed to my intellectual development. First, I want to express gratitude to my committee, not only for their assistance with this study, but for their development in me of the traits that make for better scholarship. Marv Peterson has been endlessly patient in my development, and was always willing to offer a comment or graph of his thinking that prompted me to reassess my

own. Eric Dey has been good to me over the years, providing advice and opportunities, and I thank him especially for his willingness to step in and be a co-chair on short notice. Jan Lawrence has always been willing to talk over issues in and out of class and provided me with opportunities to teach and gain research experience in areas I would not have had otherwise. I also thank Dr. Jim Duderstadt for being willing to serve on my committee even though we had no prior working relationship. I value his perspective and hope to benefit from his insights going forward.

In addition, I would like to thank Dr. Larry Rowley for our many extended conversations—most of which were not about this dissertation but about the field and academia in general—but also for his work with me on my prospectus and the issues that undergirded it (and our spirited dialogues!). I also thank Dr. Michael Bastedo for his discussions with me about the prospectus, and his insights during the early stages of my research conceptions. Thank also to Jason Owen-Smith for his consultation with me about his typology.

Many other friends deserve my thanks. Nancy Birk, for being a great dissertation buddy, overall grad school confidant, and for always checking in on me; Mark Garrett, for always being willing to talk and share his experiences; Steven Ball, for helping with some preliminary analysis of the data, while also being generally available for social outings; To the other members of my cohort, as well as those who came before and after me, that showed me how it could be done. I should also recognize Kat Irvin for all the time spent talking to me about finding my own way.

There also a few other professional people I should thank. Laura Klem in CSCAR was a valuable resource for me to discuss survey design, data analysis, and the determination of the best ways to think about my faculty typology. She offered many ideas for my endless quest to make sure I was conducting a thorough and fair analysis. Mick Couper from ISR offered to consult with me on the survey design (especially the online part) and assisted with the pre-testing. I should also thank Marvin Parnes for consulting with me on the content of the survey questions, as well as providing me the opportunity to do some work in the tech transfer office. There were many other people who participated in the survey pre-testing, but I would like to thank Brian Coppola at UM and Joan Dunbar at Wayne State for talking with me about these issues and looking over the survey. Also, the small army of students who helped with the sample saved me many hours of work. Finally, many thanks to the ASHE and AERA reviewers and discussants that offered helpful comments about the analyses for my presentations, the papers from which served as the basis for the write-up of the results and conclusions.

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ABSTRACT

CURIOSITY AND COMMERCIALIZATION:
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Thomas E. Perorazio

Co-Chairs: Eric L. Dey and Marvin W. Peterson

Given the need to compete for sponsored research funding, do university faculty believe they retain the freedom to research what is of most interest to them? The higher education literature frequently asserts that faculty research agendas are being subjugated to the demands of sponsors. An alternate perspective, from the science studies literature, posits that academic science itself is changing as some research faculty adapt to a transformed environment for knowledge production that involves new working relationships with sponsors.

However, this transformation produces an altered conception of academic science that moves away from traditional normative systems such as those proposed by Robert Merton. The literature shows that academic scientists can deviate from traditional norms of research practice, but it is not known to what value systems they are gravitating. This question requires conceptualizing academic science as a social activity, understanding that faculty adaptation involves the construction of new

organizing frameworks for science as they integrate conflicting values and experience ambivalence regarding their research demands.

Based on an original survey collecting data from more than 1200 faculty at doctoral/research universities, the study has two areas of foci concerning academic science. The primary question addresses concerns that, owing to the need to locate extramural sponsorship for research, university faculty are losing the ability to determine their own research agendas. Following analysis of multiple conceptions, levels of perceived control in different contexts reveal complex patterns of adaptation and negotiation in relation to external circumstances. A more nuanced understanding of control emerges.

The second question examines the value systems present in academic science—such as those proposed by Merton's norms—in relation to alternate views to determine whether faculty would view different academic values as legitimate or even necessary to perform research. The findings reject the notion of conventional values being predominant, and discrete types within the typology being tested were not supported. The findings indicate that faculty move among multiple value systems when conducting academic science.

CHAPTER I. INTRODUCTION AND CONTEXT

Traditionally, universities have been viewed as cultural institutions, providing general contributions to national and economic development without specific and concrete purposes (Gumport, 2000). Advancing knowledge through research is viewed as one of the principal functions of universities (Geiger, 1986, 1993; Kennedy, 1997) and is also viewed as the primary vehicle for advancing individual institutional prestige (Brewer, Gates, & Goldman, 2002; Rosovsky, 1990). University research is also viewed as a public good held in high regard by society as part of the unwritten social contract between institutions and society. This relationship has produced an expectation from government that science should provide a return to society for the public investment made, while institutions enjoy relative autonomy from government (Duderstadt, 2000a; Frodeman & Mitcham, 2000; Guston & Keniston, 1994; Rothblatt, 1995).

An alternate view is much more utilitarian regarding academic science and considers universities to be public service institutions with concrete social, political, and economic goals (Branscomb & Keller, 1998; Braun & Merrien, 1999a; Newell, 1985; Sutz, 1997). Governments fund university research with an expectation that, in addition to new knowledge, many benefits will accrue to society through a continual flow of discoveries and innovations that can be converted into new products, medicines, or services that will not only solve problems but have an economic benefit (Duderstadt, 2000a; Frodeman & Mitcham, 2000; Guston & Keniston, 1994; Rhodes, 2001).

Certainly research and development activity at U.S. universities is now an integral part of technology-based economic development nationwide. In FY 2005, universities and colleges reported Research & Development expenditures of $45.8 billion, 5.8% more than in the previous year ($43.2 billion) (NSF Division of Science Resource Statistics, 2007). The sheer volume of research and related activities have prompted states and regions to view contributions to economic development through services like workforce preparation, extension/technical assistance, and research partnerships with industry as part of the mission of higher education (Tornatzky, Waugaman, & Grey, 2002). Universities make their contribution to economies in many ways; however, since 1980, the complex assortment of activities that comprise technology transfer, development, and commercialization have been a growing resource for economic development (Palmintera, Hodgson, Tornatzky, & Lin, 2005).

The array of academic science in universities has been expanding in recent decades, resulting in more research projects conducted with some level of emphasis on applied outcomes, as well as changes like university partnerships with industry, greater scrutiny of institutions from government agencies, and increased competition among institutions for research funds (Branscomb, Kodama, & Florida, 1999; Feller & Roessner, 1995; Seashore-Louis & Anderson, 1998). However, this trend has been criticized as the commercialization of academic research (Bok, 2003; Buchbinder, 1993), a turn of events that undermines the ideal of the university (Giroux, 2003; Rosenstone, 2001). As these events occur in a context of a knowledge-based society, the question of how academic

research has changed is often raised (F. Newman & Couturier, 2001; Press & Washburn, 2000; Shils, 1997b).

To be sure, the current environment for university research is being dramatically altered by the social, political, and economic demands placed on universities (Dill & Sporn, 1995b; Gumport & Pusser, 1999). Frequently, this shift is identified in the higher education literature as a market or industry emphasis on research (L. Cohen, McAuley, & Duberley, 2001; Gordon & Whitty, 1997; Gumport, 2000; F. Newman & Couturier, 2001), in which institutions engage in sponsored research to acquire funds. Such changes are perceived as undermining institutional autonomy and institutional missions (Beck, 1999; Kurasawa, 2002) because of the fear that institutions will be beholden to the interests of the funding providers, and because of the potential for knowledge to be recast as a commodity to be sold (Berg & Roche, 1997; Kelsey, 1998; Rosenstone, 2001).

Observers of research universities, both within and outside higher education, are concerned that the demands of this environment are forcing universities toward the production of practical benefits through applied research. This is seen by some critics as supplanting basic or pure research—that which is undertaken to produce knowledge without regard to its immediate societal benefits—and causing institutions to serve the interests of the providers of their research funding, to the detriment of the greater public trust (Buchbinder, 1993; Hicks & Hamilton, 1999; Press & Washburn, 2000; Shenk, 1999; Shils, 1997b; Sommer, 1995). Such critiques accuse institutions of succumbing to the commercial pressures of the marketplace (Bok, 2003; Giroux, 2003), embracing applied research for industrial interests, and other entrepreneurial activities

(e.g., Clark, 1998; Slaughter & Leslie, 1997), which force them to move away from their responsibilities to fundamental research as they strive to become more self-sustaining (Bridges, 1998; Rhoades & Slaughter, 1998).

Concurrently, other literature from science studies contradicts this point of view, contending that the traditional viewpoint associated with the Vannevar Bush model of linear innovation flows from universities outward to society is outmoded. Recent critiques of the linear model (Branscomb & Keller, 1998; Etzkowitz & Leydesdorff, 1997; Stokes, 1997) have emerged as science scholars see other methods for collaboration between universities and society. Indeed, the transformation of research can be approached from several perspectives (Delanty, 2001b; Jacob & Hellström, 2000). One method could include the traditional, cultural critique regarding the purposes of the university (Readings, 1996; Shils, 1997c; Soley, 1995). A more complete approach would consider how academic science is becoming more integrated with society as universities conduct research in a globalized environment (Etzkowitz & Leydesdorff, 2000a, 1997; Gibbons et al., 1994; Nowotny, Scott, & Gibbons, 2001).

Writings in this literature share a common theme of university research having the ability to accommodate both academic and market values (Slaughter, Archerd, & Campbell, 2004). This viewpoint argues that entrepreneurial activity comes from the economic contribution universities can now make to their societies (Etzkowitz, Webster, & Healey, 1998b; Sutz, 1997; Tornatzky, 2000). From this vantage point, universities are encouraged to be more creative and proactive in their use of intellectual capital, engaging with new and different sectors of society to form partnerships for research

(Goldstein, Maier, & Luger, 1995; Gray, 1999). This external engagement presupposes that innovation is now a globalized process and globalization challenges the policy idea that there are self-contained national systems of innovation (Branscomb & Florida, 1998). There is a growing belief that research universities will need to look and function differently in a society that assigns both economic and intrinsic value to knowledge (Birch, 1988; Delanty, 2001a; Duderstadt, 2000b; Jarvis, 2000, 2001; Smith & Webster, 1997).

The Problem

Pinpointing the specific effects of globalization upon universities is difficult because any evidence of difference has to be observed at the micro-level, either within research units or among individual faculty (Laukkanen, 2003; Tuunainen, 2006). While the arguments surrounding these issues are complex, this study will focus on the circumstances of individual faculty members—the control they exert over their research agendas. For this study, that means the processes used by university faculty to select research topics, including the values associated with the work.

The primary objective of the study is to learn how adaptation to this environment is influencing the values faculty associate with academic research. Faculty from different disciplines within universities may feel the competitive environment for funding research is inhibiting their ability to determine their own research agenda—that is, to conduct research in the areas of inquiry most of interest to them—while others may view the changes in their work as conditions necessary to advance their research.

This study will attempt to ascertain the extent to which faculty believe they can negotiate these changes and retain control over their research (Anderson & Seashore-Louis, 1991). Defenders of curiosity-driven research argue that market or regulated systems of research would not yield the same broad portfolio of research that the current system for basic research does (Strandburg, 2005).

If academic science is truly being transformed, then is there evidence that the values associated by faculty in various disciplines regarding what qualifies as good science differ? Testing for disciplinary differences is important as faculty situated in different contexts may have dissimilar perspectives (Braxton, 1986; Fishman, 1978). The perceived norms perpetuated in those environments could either replicate traditional research practice, push faculty toward modern models of research, or support faculty regardless of chosen methods. More specifically, we should know what evidence exists that there are different narratives regarding academic science amongst faculty, either within or across disciplines.

The purpose of this study is to determine whether faculty believe they retain the freedom to research what is of most interest to them. However, our understanding of what it means to control one's research agenda may be altered by the changing nature of academic science. Thus, it becomes important to know whether the traditional norms and values regarding what constitutes proper academic science still frame the understanding of research faculty. Given this consideration, the secondary purpose of the research is to know whether academic scientists hold traditional or alternate value systems about academic science.

Thus, the research questions for two primary components of this study will be:

1) To what extent do university faculty feel the process for obtaining research sponsorship is compromising their ability to control their own research agenda?
2) Is there evidence to suggest the existence of alternate normative/ value systems among faculty regarding what constitutes academic science that differ from traditional ones?

Theoretical Perspectives

The idea of "control" is important in two respects for this study because it is at the heart of the theories used for this research. First is the question of whether faculty retain control over their research, or whether it has become subject to "dispersed influence" (Anderson & Seashore-Louis, 1991). Essentially, this is an academic freedom issue, with autonomy being the primary factor. Although this autonomy is present at the level of academic departments and disciplines through mechanisms such as peer review, this study is focused at the level of individual faculty. Subject to compliance with ethical and scientific norms, faculty are generally free to direct their own research programs. The notion of dispersed influence refers to the external factors that have come to influence faculty, including governments, industry, interest groups, regulatory agencies, as well as academia itself.

Control is important in a second way in relation to the scientific norms mentioned above. The academic profession exerts some social control over faculty through an expectation of compliance with the norms of science (Braxton, 1986, 1990, 1993). Conformity has been a subject of study for decades (e.g., Hagstrom, 1965), as other academic scientists view the norms of science as essential to the advancement of

knowledge. The normative structure of science (Merton, [1942] 1973) is an important issue in the field of the sociology of science, and the examination of those norms will be a critical component of this study.

Regarding control in this manner, the first theoretical perspective informing the study is institutional theory (Powell & DiMaggio, 1991; W. R. Scott, 2001) and theories concerning social conventions, traditions, and accepted practices, as well as how such institutions adapt. According to Scott (2001), institutions are "social structures that have attained a high degree of resilience" (p. 48). Institutional theory posits that practices and behaviors become embedded over time as systems that define social thought and action. Performance in accord with these social systems provide legitimacy to actions and new entrants, producing isomorphic tendencies (DiMaggio & Powell, 1991a, 1991b).

The current study will use the conception of academic science as an institution—a set of processes agreed upon through convention and tradition—and examine the values faculty exhibit in practice. In particular, the institution is the normative structure of science as conventionally understood, since it has such a large influence over current notions of academic science—perhaps existing as a governing ideology (Mulkay, 1976). Given its design, this study is not attempting to isolate instances of institutional change, but will attempt to uncover evidence of new institutional forms and evidence of difference that may already be in existence.

Any differences uncovered in the norms of science could be attributable to the new circumstances outlined by the second theoretical perspective for the study. With

the shifts resulting from globalization as context, this area of study is concerned with the transformation of knowledge production and academic science, which parallel wider transformations in society (Etzkowitz & Leydesdorff, 1997; Etzkowitz et al., 1998b; Gibbons et al., 1994; Leydesdorff & Etzkowitz, 1996; Nowotny et al., 2001). Globalization creates new roles for university researchers and affects the manner in which they conduct research and interact with colleagues to pursue knowledge. Universities become important to the knowledge economy as the boundaries between actors, sectors, and disciplines become less relevant.

Rather than explaining the changing organization of knowledge production (e.g., Clark, 1998; Slaughter & Leslie, 1997), these theories attend to the changing processes for creating new knowledge—apart from any particular organizational structure—and consider the impacts globalization is having on the contexts for innovation. In describing a "socially distributed system of knowledge production"(Gibbons et al., 1994), "non-linear systems of innovation"(Etzkowitz et al., 1998b), and a "dynamic model combining understanding and application" (Stokes, 1997), this literature presents important implications for the sociology of science and its consideration of norms.

This study will build on work by Jason Owen-Smith and Walter W. Powell (2001), who proposed a typology of faculty views of academy-industry relations (see Table 1 below & Figure 3, p. 105). This model was derived from a qualitative study of faculty in the life sciences, but has not been applied to other disciplines. While a fuller explanation of the model will be provided in the literature review and methods sections, the typology allows for comparison of faculty along several dimensions relevant to the

tensions articulated in the debate concerning traditional vs. (post)modern academic science. It conveys the complexity with which the research environment is negotiated, outlining the "old school" (traditional) and "new school" (modern) positions on academic science, while also discussing "hybrid" responses and acknowledging that there are faculty who bridge the gap between the extremes (Owen-Smith & Powell, 2001). Through this model, traditional notions of academic science, as embodied in the Mertonian norms of science (Merton, 1942/1973), can be contrasted with perspectives on the transformed environment for science (Ziman, 1996). The hybrid positions outlined in the model could be evidence for new institutional forms.

Table 1: Typology of Academy-Industry Relations

		COMMERCIALIZATION OF RESEARCH	
		Threatens Academy	***Does NOT Threaten***
ACADEMIC & COMMERCIAL SCIENCE	***Distinct***	Old School	Engaged Traditionalist
	Overlap	Reluctant Entrepreneur	New School

Note: Adapted from Owen-Smith & Powell, 2001.

This study will test the model proposed by these authors to determine whether it can be used to describe variations in values about academic science amongst faculty from different fields. Specifically, the test will focus on the authors' idea of hybrid positions located between the extremes on the spectrum and whether distinct values and practices can be attributed to those positions. Tests for the existence of such positions are required before we can determine the extent to which science is truly being altered (Tuunainen, 2006).

Context for the Problem

Globalization as Opportunity for Transformation

A full consideration of globalization is beyond the scope of this document, but is mentioned here because it is bound up with the transformations of society discussed in the literature on the changes to knowledge production. Authors critical of alterations to university research argue the globalization of the political-economy is to blame for compromising academic science because it undermines the nation-state, which supports and legitimizes universities (Burbules & Torres, 2000; Currie & Newson, 1998). Globalization—it is argued—results in less political will for government financing of institutions, a greater demand for commercialized knowledge to generate productivity and wealth, and the rationalization of higher education (Ball, 1998; Braun & Merrien, 1999b; Dill & Sporn, 1995b; Henkel & Little, 1999; Neave, 1995, 2000). In this view, the reduction of government provisions creates market-like circumstances (Slaughter & Leslie, 1997), where the continual need to locate new research funding has the potential to compromise the research agenda of institutions and their faculty, thereby compromising the public good (Kezar, 2004).

Certainly, part of the transformation of society resulting from globalization is that knowledge and information, rather than labor, materials, or capital, have become the key resources for advancement and growth (Drucker, 1994). The restructuring of the economy towards a "postindustrial society" (Bell, 1999) foregrounds new science-based and professional service industries in which knowledge workers rely on technical information and learned skills to produce innovations and create new knowledge

(Barrow, 1996; Brint, 2001; Castells, 2000). However, the idea that globalization is only about economics and markets (e.g., Ball, 1998; Carnoy & Rhoten, 2002; Rhoads, 2003) is a misconception common in the education literature. There are contentions that higher education has been colonized by the market (Kurasawa, 2002), that the state is exerting power mechanisms of steering and evaluation to drive institutions towards economic ends (Braun & Merrien, 1999a; Whitty, 1997), and that higher education is being forced down a "single path" method of neoliberalism globalization (Newson, 1998).

While the economic dimension is certainly important, considerations from the broader social sciences argue that what makes globalization a transformative force are its effects in other realms of our lives (Appadurai, 1990; Giddens, 2000; Held & McGrew, 2003). Peter Scott has recently said "globalization is more than market-led techno phenomenon. It is bound up in the larger development of a knowledge society, and also intimately linked to changes in knowledge production" (P. Scott, 2003, p. 212). As one globalization theorist notes, it is impossible to truly understand globalization using the simple lenses of either economic or technological determinism. Science, technology, and capitalism evolve together in the system of globalization. Viewing globalization as simply the imposition of neoliberalism and the logic of capitalism on all parts of the world fails to see the transformations the scientific and technological revolutions are producing (Kellner, 2002).

Both in concept and reality, globalization refers to the collection of forces that make the world seem a smaller place, primarily due to the integration of national politics, economics, cultures, and technologies such that people become more

connected and interdependent in these capacities. Societies are integrated and become transformed as individuals are influenced by these changes and integrate new attitudes, values, beliefs, and practices into their lives (Brawley, 2003; Friedman, 2000; Levin, 2001; Sklair, 1999).

One aspect of globalization particularly important for this research is the idea of localized agency—or "localism", which is supported by several theories of globalism. Robertson's (1992) conception includes the idea of the shrinking world but also touches on the human awareness of the phenomenon, while Waters (2001) highlights the growing consciousness that people have about their globalizing world as a key to their understanding how transformation occurs around the world (Robertson, 1992). *Reflexivity* is a key component of the social changes resulting from the development of a knowledge-based society. Because knowledge is generally empowering, people can use their increased access to knowledge to shape all aspects of their lives. In addition, they use knowledge to acquire more knowledge and gain expertise in multiple contexts (Giddens, 1990). Closely related to reflexivity is the concept of *relativization* (Robertson & Chirico, 1985) in which individuals can place themselves in a larger context and be self-reflective on their situation.

As applied to higher education, universities and individuals within them have agency regarding their increased integration into society. As knowledge institutions, universities are uniquely positioned to stake out their futures. Marginson & Rhoades (2002) offer a heuristic for understanding this circumstance, recognizing that universities can choose to view themselves as global, national, or local institutions, or as

existing in all three domains simultaneously. Their *glonacal*-agency heuristic combines the three levels while also recognizing the concept of self-directed action, or agency. Their model allows for the multiple flows of information and influence on institutional decisions. At a local level, faculty members exhibit agency to adapt their research, for instance, to the transformed knowledge production process (Owen-Smith & Powell, 2001). The review of literature on the transformation of science will discuss this further.

The concepts of localism, local agency, and reflexivity are important for the analysis of how faculty negotiate the new research environment and make choices regarding the manner in which they direct their own research agendas. If there are indeed different value systems among faculty, decisions by individual faculty, perhaps reinforced by different research support structures, could be causal factors explaining—to some extent—the existence of other value systems for science.

Significance

The primary importance of this study is that it will empirically examine an issue that is typically assumed away in the higher education literature—that university research professors are losing their ability to pursue the lines of inquiry of most interest to them because the process of locating external funding, and the providers of that funding are either limiting or directly controlling the research agenda. Also, the study explores the larger question of the changing nature of academic science through the examination of faculty values, attitudes, and practices within these circumstances. Through this study, we will learn more regarding how research faculty are balancing traditional and newly emerging ways of doing their work.

Overview of the Study

Following this introduction, the literature review discusses modifications to the scientific ethos as academic science undergoes a transformation, summarizes the effects this has on faculty values including control over their own research, and outlines how the institutional theory can be a means for understanding how faculty adapt to the altered environment.

The methods chapter presents the primary and secondary research questions, along with the sub-questions the study will also address. The research design and analytical model are introduced, and the variables of the study are put forward with their accompanying research questions. The chapter also outlines the data collection procedures, the analysis plan for each research question, some preliminary analysis and data manipulation, and a description of the respondents.

The results chapter first presents a summary of the independent variables from the survey, and then moves into an analysis of the variables associated with the faculty typology used for this study. Following that is an analysis of the concept of control over research agendas in two different capacities. First is a consideration of four potential scenarios or outcomes between faculty and their sponsors. The second consideration is the primary dependent variable for the study: control over research as measured by a multi-item scale.

The final chapter presents findings and conclusions about the questions asked and the variables studied, as well as the methods and theories that were used in the conception and implementation of the research.

CHAPTER II. LITERATURE REVIEW

The review of the literature will encompass several theoretical and empirical areas that are important for understanding the rationale for this study, the questions asked, and the variables used. There are three primary sections, followed by a synopsis.

The first section will discuss academic science from the perspective of the sociology of science and what it reveals about the normative structure and values associated with research practice. The contrasting viewpoints will be discussed, the transformation of academic science is posited, and the idea of these norms as institutions will be introduced.

The next section will examine the effects of the transformed environment for academic science on university faculty. The section will consider the academic freedom issues in the primary research questions about controlling one's research agenda vs. the influence of sponsors, and will introduce topics that will be used in the examination of the norms of science and the dependent variables. There is also a consideration of five common issues that will be used in the analysis of faculty value systems.

Finally, the third section will consider institutionalism, or institutional theory, and what that perspective offers regarding stability and change within organizations such as universities. Specifically, the section will focus on how individual actors possess the agency to adapt and even create new institutional forms and logics from long-

established social structures. Institutionalism offers a conceptual explanation as to how alternate value systems could exist for faculty to employ.

The synopsis presents concepts that emerge as important for the two main components of the study: the concept of control as related to faculty research agendas, and the examination of normative systems of values regarding academic science.

The Scientific Ethos

Traditional Norms of Academic Science

As stated in the introduction, part of this study will ask faculty about the traditional norms of academic science as compared to ones developed more recently, such as entrepreneurialism. Although there are other theoretical areas concerning the normative structure of science, these two areas are the most developed and are most often discussed in opposition in the literature (Slaughter et al., 2004). Generally, the debate is undertaken within the sociology of science, which is a field of inquiry focused on the norms associated with the processes of research activity. This field is separate from science as a body of organized knowledge, investigatory techniques, or even from the sociology of knowledge (Barber & Hirsch, 1962; Merton, 1957b; Storer, 1966; Whitley, 1972).

The sociology of science can be traced back to the work of Robert Merton ([1938] 1973, [1942] 1973) and Talcott Parsons (1951), who were recognized as early leaders in the sociology of science (Barber & Hirsch, 1962). Our understanding of what is now referred to as the structuralist-functionalist model of the norms of science

(Braxton, 1986; Hess, 1997; Slaughter & Rhoades, 1990) was developed by Merton, Parsons, and others (Barber, 1952; Storer, 1966). These early writings share a related set of values about what constitutes scientific inquiry, how scientists should approach their work, and what criteria should be used to evaluate science.

In its early development, the sociology of science was viewed as primarily concerned with the internal functioning of the community of scientists, and not with the relation of science to society as a whole, although some early writings (e.g., Merton, [1938] 1973) that serve as the foundation for the field did address the relationship between the two. As the field developed, the interrelations between science and society became more prevalent as a topic for inquiry (Kaplan, 1964), but the emphasis on science as a social system was the initial focus. The field differentiated between the technical norms and the moral norms of science. Technical norms involve the scientific method; moral norms discuss the role of individual researchers in the larger social system of scientific inquiry and what behaviors are appropriate for that role. These moral norms comprise what is referred to as the scientific ethos—a system of practice for academic scientists (Fishman, 1978; Randazzese, 1996).

Indeed, a study by Hagstrom (1965) called *The Scientific Community*, examined the socialization of academic scientists by their peers, and found that colleagues had the most influence upon one another in how basic research was conducted. "Community" meant regulating activity through social norms, controlled through the motivation of peer recognition. Barber (1952) considered science as a social activity emerging from the human need to exert rationality over the natural world. He examined "the social

organization of science," discussing it as a "moral enterprise" (p. 122), in which the authority of the individual scientist is derived from the moral authority of science as a whole. Storer (1966) asserted that science is best viewed as a social system concerned with extending empirical inquiry that is guided by a set of shared norms that define the relationships among its practitioners.

The social context for the scientific ethos is critical to understanding its logic. Owing to the time of their development, the early theorists share a perspective of an oppressive state, signified by the totalitarian regimes of the Third Reich and the Soviet Union. These governments were hostile to science because they demanded the subordination of all institutions, including science, to the state. Merton's theory, in particular, is important because it outlines how the social institution of science functions within the open cultural mores of democracy, while defending the autonomy of science with respect to other social and political institutions (Richardson, 2004). In all these theories, the practice of science was seen as compatible only with certain type of cultural conditions, namely a liberal democratic social order. Science and modern society become mutually supporting (Barber, 1952; Merton, [1938] 1973, [1942] 1973).

Writing about threats to science in 1938 during the rising threat of the Nazi state, Merton was concerned about science at a time when it was coming into question. He outlined how science cannot be judged according to political or religious authority, but must instead retain its purity, autonomy, and impartiality. Purity is science pursued for it own sake, and not for any utilitarian ends. Autonomy ensures that the scientist is free from intrusions from other institutions or segments of society. The notion of

impartiality holds that scientists should neither be concerned nor responsible for applications of scientific discoveries. However, some aspects of impartiality are paradoxical and have implications for continued support of science; some application of science is necessary for continued public support, as the public will not support science continually on faith alone. However, a sole focus on methods and pure knowledge can lead to disregard for the social implications of certain applications of science, which could undermine public support (Merton, [1938] 1973).

In trying to articulate the place of science in the social order, Merton viewed it as a moral enterprise incompatible with the ascendant political ethic. Merton wanted to outline a scientific ethos that would judge theories based on logic and facts, rather than use irrelevant political considerations. Emphasizing the cultural structure of science, Merton said, "The ethos of science is that affectively toned complex of values and norms which is held to be binding….The norms are expressed as prescriptions, proscriptions, preferences, and permissions. They are legitimized in terms of institutional values. These imperatives, transmitted by precept and example and reenforced by sanction are in varying degrees internalized by the scientist…" (Merton, [1942] 1973, p. 268-9).

With the goals of understanding larger institutional structures that govern science, Merton offered four "institutional imperatives" (p. 270) as comprising the ethos of modern science (Merton, [1942] 1973):

Universalism

The norm of universalism refers to the absence of bias and emphasizes that findings not be judged using pre-established personal criteria. Objectivity, rather than a particularistic focus on the personal qualities of the researcher or the tenets of certain creeds, is required. This norm is also extended to the careers of scientists themselves; inclusion into the realm of science must be based on competence alone and not immutable characteristics or pre-existing social status (Merton, [1942] 1973).

Communality (Communism)

The term communism here is concerned with the common ownership of the products of science, and is generally replaced by the term "communality". As findings are products of social collaboration, they belong to the community of scientists. The intellectual property of the individual scientist is defined as recognition, credit and esteem among peers for discovery, known as "priority". Open communication among scientists through publication is required for the furtherance of knowledge; secrecy is antithetical to the sense of shared heritage and cumulative knowledge embraced by scientists. Thus, patenting and exclusivity present a conflict (Merton, [1942] 1973).

Disinterestedness

The reputation of science is dependent upon scientists carrying out their activities with integrity and refraining from exploitation of their work for personal gain. Individual scientists cannot be concerned with surpassing competitors in recognition.

Accountability in science comes from mutual policing performed by peers (Merton, [1942] 1973).

Organized Skepticism

Science requires that established ideas, authorities, and institutions be subjected to detached scrutiny. In this process, the researcher must suspend judgment pending receipt of all the evidence. This norm often places science in conflict with many aspects of society, as scientific questioning can be perceived as undermining that which is studied (Merton, [1938] 1973, [1942] 1973).

These norms have come to be called "Mertonian", a term also descriptive of a particular type of science conducted in accordance with them. The mores and norms were not valued simply because of the efficiency with which the methods derived from them produce valid results and reliable predictions, but because they were believed to be right. Merton also linked these norms to the reward system in science, indicating that those who adhered to these norms would receive the most peer recognition (Merton, 1957b).

Parsons focused on science as an occupation and discussed the scientist as a professional with specialized knowledge; he outlined the norms for scientific knowledge and the role of scientists. In the Parsonian view, science is based on occupational values including universalism, affective neutrality, specificity, and achievement-orientation. However, the most important consideration for scientists is the value of collectivity-orientation, also known as an "other-orientation" (Parsons, 1951, p. 144). This is important because of the power that accrues to the scientist. Similar to communality,

any scientist with simply a true self-orientation could interfere with the public interest given the potential power of any knowledge discovered, were it to be held apart from society. Furthermore, a self-oriented scientist could monopolize scientific knowledge and hinder the work of others. Two other critical and related values are tentativeness and the acceptance of evidence, which have parallels with organized skepticism. Together, these values stipulate that all findings must be treated as provisional until sufficient evidence is presented to prove them, and that scientists are obligated to accept findings as valid once such evidence in presented (Parsons, 1951).

Barber also wrote about the relationship between science and modern society, claiming that, similar to Merton, certain cultural values are required for science to flourish (Barber, 1952). More to the point of values governing scientific activity are several values shared between science and society as well as some particular to science. Convergence with other normative systems is again evident. First is the scientific value of emotional neutrality. This should not be misconstrued as excluding conviction or passion for science, but does enjoin scientists to refrain from emotional involvement that leads to deception or distortion of scientific activity. Second, universalism emphasizes merit as a criterion for achievement or assertion of scientific truth rather than immutable characteristics such as race or gender. Third, individualism expresses self-reliance and the responsibility to judge scientific validity based on one's conscience rather than the dictates of formal, organized authorities. Adherence to the discipline of scientific norms and values of science becomes each scientist's duty (Barber, 1952).

Those values that are more apiece with science include communality, or what Merton called communism. Again, it describes a value at-odds with a society that prefers private property rights; communality requires only the absolute minimum of secrecy necessary to ensure credit and priority of discovery. Beyond that, all intellectual products are viewed as contributing to the common store of scientific knowledge. A value also not shared by society at large is disinterestedness, similar to what Parsons' "collectivity-orientation" (1951, p. 144). This value compels scientists to serve one another and the greater scientific process, thereby facilitating the community regarding scientific innovations (Barber, 1952).

These sociological writings outline a scientific ethos that, although embodied by Merton's norms, is inclusive of all the values discussed. The ideal scientist is perpetually objective, neutral, disinterested in results, and has only the joy of discovery and the needs of society as motivation. This traditional conception of science continues to drive how the science as a profession should operate, how individual scientists should approach their work, how the community of scientists interact with and police one another, and how society should look upon scientists and their work.

Theoretical & Empirical Criticisms of Mertonian Science

A critical treatment of Merton's norms may begin with Merton himself, who, in later writings (1957a, 1963), focused on the academic reward system—in particular, the notion of priority of discovery—and the potential value conflicts it presents to academic scientists. By the early 1960s, Merton described a phenomenon called 'sociological ambivalence' based on the potential for contradictory demands in any social institution.

In academia, this has an effect on the actual practice of and relations between scientists; the cognitive dissonance generated by this ambivalence forces them to combine competing values into consistent action. However, before finding the proper course of action, it is normal for scientists to exhibit behaviors that deviate from the ideal ones (Hess, 1997; Merton, 1963). Given the potential for any number of scientists to deviate from the moral norms at various times, conformity to the norms may exist at the scientific community level but not necessarily among individual scientists (Hagstrom, 1965).

The Merton-Parsons-Barber system of values has been criticized as assuming the norms to be unchanged since their 17th century origins, insisting they were universally applicable, and accepting them without sufficient empirical verification (Fishman, 1978; Hess, 1997; Kaplan, 1964; Knorr-Cetina, 1991). Other sociologists of science have held that when science expanded into its larger, modern form, the traditional norms perhaps became less applicable as science became more accountable to society (W. Hirsch, 1968; Richter, 1972).

Rather than seeing science or its norms as universal, or the advancement of knowledge as a purely intellectual pursuit, Sklair (1972) asserts science must be viewed as a social activity. He criticizes the notion that science can only function in liberal-democratic states, since the ideology of pure science is violated by Western states through regulatory restrictions—such as human subjects review—on certain aspects of scientific activity. Violations of other norms result from secrecy via national security or business interests. Regarding the reward structure in science, Sklair disparages

Merton's view on the priority of discovery, saying that if the perpetuation of science depends on each person receiving credit for originality, then we would expect scientific activity to cease if proper credit was not given. Sklair says Merton's theory falls down in two respects: that the competition for priority is not universally critical to the advancement of science, and to the extent that it is, it reinforces the concept of science as a social institution.

Other empirical research has failed to prove the existence of Merton's norms, or widespread compliance with them in total. Indeed, the attempts to verify the existence of the norms have often resulted in substantial deviation from the norms in practice. In one early study, based on interviews with 57 faculty in several science disciplines at one university, considerable deviation from the ideal of "no exception" to the norms was discovered (West, 1960). Despite the small and restricted sample, the author concludes that the idea of a firm consensus regarding scientific values may be a myth. Other early studies found no pervasive influence of the norms in totality; instead, particularistic and situational norms were applied by scientists and academic departments. For instance, the norm of universalism was shown to be violated in studies of status attainment in academe (Crane, 1965; Reskin, 1976), revealing that advancement and recognition accrued to those scientists with a more prestigious institutional affiliation, rather than with higher levels of productivity. Pre-doctoral research productivity was also shown to be less important to departments hiring candidates for initial positions than the prestige of the degree-granting institution as well as who recommended them (Long, Allison, & McGinnis, 1979; McGinnis, Allison, & Long, 1982).

The Mertonian norms have also been criticized for producing a vision indicating that science functions as a non-problematic set of tools that all users can apply with equal objectivity and quality to all questions (Whitley, 1972). Having the sociology of science focus solely on relations among individuals and how they practice their craft divorces it from the sociology of knowledge, which objects to a unified view of knowledge or methods for inquiry. This leads to a "black-box" vision of science, in which we can only study the applications of norms among producers of knowledge, not the actual process of knowledge creation itself.

Mulkay questioned the extent to which Merton's norms represent the true nature of the process for discovery (1969). Directly contrary to the early sociology of science, he asserted that the true normative structure of science lay in its technical, rather than moral norms, and that theories and methods of inquiry govern the social activity of scientists. As evidence he cites the general lack of conformity to the social norms, as well as the notion of substantial resistance to innovative discoveries by scientists. The socialization of science indeed occurs in scientists' training, and this produces resistance to innovative ideas in various fields by scientists that cling instead to disciplinary conventions. Also, the social norms are criticized as lacking any consideration of the relationship between the technical processes and methods of science and its structure of social roles (Mulkay, 1969).

Picking up on Merton's concept of ambivalence, an important early study that is often cited (e.g., Braxton, 1986; Etzkowitz, 1989; Ford, 2000; Mulkay, 1976) provided support to this theory by positing that the traditional norms may be offset by opposing

norms (Mitroff, 1974). Based on a series of four interviews each with 42 scientists on the Apollo moon project over three-and-one-half years, the study presents a substantial amount of first-hand, empirical evidence to demonstrate that scientists do in fact use variations of the traditional norms in their daily work. In fact, Mitroff asserts that there are two sets of norms required for science to advance. The subjects in the study emphasized the deeply personal commitment required to produce quality scientific work, and that the idea of completely objective, impartial, and impersonal scientific work does not comport with reality. Furthermore, some level of secrecy is needed to protect priority of discovery and to prevent others from borrowing unpublished ideas and methods or anticipating results with similar studies.

In summarizing the results, Mitroff proposes a set of counter-norms. Emotional neutrality is offset by *emotional commitment* that allows for long-term dedication to solving difficult problems. Universalism is countered by *particularism*, which acknowledges that scientists do have networks of sources and colleagues whose work they regularly consult because of a belief as to its quality, thus allowing for personal knowledge of the individuals as a factor. Communality is balanced by *solitariness* or secrecy, which allows findings to be held for a reasonable amount of time to protect priority, or to assure that findings are complete and reliable before publication. Disinterestedness is offset by *involvement* or interestedness, allowing for scientists to achieve satisfaction through service to communities of interest in particular subject areas. Finally, organized skepticism is balanced by *organized dogmatism*. This states that scientists must assert belief in their own findings, doubt those of others, and that

the intellectual work of others that serves as the basis for one's own work must be clearly identified and differentiated so that error and credit can be properly assigned (Mitroff, 1974). In summary, Mitroff believes that a balance between these norms is required and that none be used exclusively: "…each norm is restrained and if any were unrestrained, science would probably collapse" (p. 593).

However, even the idea of norms is not universal. In a discussion of scientific norms, Mulkay (1976) disputes the claim that the moral norms or counter-norms of science are institutionalized in any way, contending that they are instead an ideology. He sees them as vocabularies of justification, or a narrative, that scientists have used to justify and evaluate scientific work to obtain public support. Asserting that neither the academic reward system nor the practice of collaboration within scientific networks imposes an institutional structure, the gradual professionalization of science from the mid-19th century through the 20th required a view of science both worthy of government support and deserving of freedom from government interference. Only a narrative presenting values such as independence, objectivity, and universalism could convince the lay public of these needs.

More recent examinations of Merton's norms in the literature from the sociology of science also reveal deviations by individual academics and institutions. A thorough review of the literature on Merton's norms in academia (Braxton, 1986) found that "social control by the community of the academic profession is, at best, loose" (p. 310). The review found evidence of deviations based on the competition for priority of discovery and secrecy, although the norm of communality had broad acceptance. In

addition, the review revealed selective violations of universalism—conditional upon the level of paradigmatic development in various fields—instances of the Matthew effect, which describes cumulative advantage to individuals and departments already having prestige, and confirmations of violations of universalism in academic hiring and recognition.

Two later empirical studies by Braxton (1990, 1993) use data from the 1977 Survey of the American Professoriate to examine deviancy from Merton's norms, as reported by faculty. Both studies use deviation from each of the norms as four dichotomous dependent variables and control for the academic discipline and research emphasis of the faculty member's institution. The earlier study, using a sample of 795 faculty who were still active in one of seven chosen disciplines at that time, examines control theory (internal regulation of professional conduct by a community) as a basis for upholding the scientific norms. Results indicated that one's personal internalization of norms and perception of collegial conformity to the norms each had an independent effect on deviation from all four norms. Each effect had inverse effects on deviation, as less internalization and less collegial conformity led to greater deviation. That the effect of these two forms of control had a greater influence than either academic discipline or research emphasis of the institution is cited as support for control theory (Braxton, 1990).

The more recent study (Braxton, 1993) examines anomie theory (Merton, 1938) as an explanation for deviation from scientific norms. Anomie theory holds that groups develop goals and norms to which individuals can aspire to achieve success. If persons

believe they cannot achieve group goals by socially legitimate means or adherence to the norms, they will deviate from the norms, experiencing the perceived injustice as alienation from the group system.

Again using the four dichotomous deviation variables while controlling for academic discipline and research emphasis of the institution, the effect of a measure of alienation is tested, based on a scale of items from the 1977 Survey of the American Professoriate. The alienation scale represents a set of beliefs that people advance in academic careers on criteria other than merit, thus causing alienation from the rewards system. Results showed support for anomie theory as an explanatory factor for deviation for three of the norms—the exception being organized skepticism. The potential explanation for this exception is based on the notion that organized skepticism governs individual behavior more so than it does relationships with colleagues (Braxton, 1993).

Recent discussions of the institutional sociology of science (Bucchi, 2004; Hess, 1997; Knorr-Cetina, 1991) seek to recognize the contribution of Merton and this tradition to the study of the sociological structure of science. However, there is also a recognition that the field has moved beyond the structural-functionalism of this literature. This movement—variously called the "new sociology of science", "the sociology of scientific practice", "the sociology of scientific knowledge", "science and technology studies", or simply "science studies"—has sought to include what the Mertonian tradition excluded: the social aspect of the scientific process itself.

In the modern sociology of science, research models focus on "interest, conflict, and interaction" (p. 524) in scientific conduct (Knorr-Cetina, 1991), based on the belief that the cognitive aspects of science—the technical components that Merton and Parsons divided from the morals and values of science—are critical to understanding the substance of science. In the modern sociology of scientific knowledge, the entire "content" and "context" of science is open to study. This includes "how social factors shape or permeate relatively technical questions such as design choices, methodologies, theories, the interpretation of observations, and decisions about what to observe in the first place" (Hess, 1997, p. 52). Scientific research is recognized as simultaneously belonging to many social groups, including intellectual communities, academic disciplines, institutions, as well as cultures, social classes, and political ideologies (Bucchi, 2004). This notion of socially constructed science will serve as a jumping off point for the development of a modern view of the scientific ethos.

Toward a Modern Ethos for Academic Science

The question of what should constitute academic science is bound up with the contested terrain regarding the legitimating idea of the university. Much of this debate deals in abstractions, focusing on theoretical constructions of what universities should be. These debates can be summarized within three general traditions: *idealism*, *functionalism*, and *rationalism*. However, rather than viewing them as competing, mutually exclusive visions, these traditions can be represented as different layers of organizational forms. The idea of layers is useful because it represents the reality that as universities face greater demands and acquire new tasks, they do not unburden

themselves of previously existing ones; new expectations are added to the old ones. The three organizational forms conceive of the institution as a public agency, a cultural institution, and a corporate enterprise (see Bleiklie, 1998). This discussion is important for understanding how the changing nature of academic science serves to make the role of the university more complex, rather than just implementing wholesale change.

Idealism, which views the university as a *public agency*, is a tradition grounded in the British and German universities of the 19th century in which teaching and research were revered and often critiques the modern incarnations of the university against the idealism from an earlier time. It celebrates the autonomy of the individual institution, academic freedom, and freedom from state interference. The role of the state is to act as protector and guarantor. In terms of research, the idealistic tradition holds that the knowledge produced by university research is important in its own right and needs no practical outcomes to justify it. Thus, globalization and its attendant policies are forcing universities to undertake practices that undermine their true missions (Bleiklie, 1998).

However, even the idealistic tradition fails to possess a unifying idea. Cardinal Newman's original idea of a university (1982) favored liberal education over research and discovery, saying that other institutions should conduct scientific research because it wasn't the place of universities to pursue useful knowledge. In contrast, the modern research university was shaped by the 19th century German tradition of universities and the philosophies of Wilhelm von Humboldt. It was Humboldt who believed institutions should be places of scientific and scholarly research and, through the unity of teaching and research, allow for the education of students through training in research. Many of

the modern organizational and professional beliefs about how institutions should operate were established through this process, including the dependence of universities on the nation-state for its support and legitimacy (Shils, 1997a).

Lord Ashby wrote in his treatise on the development of higher education in former colonial nations that universities must do two things to ensure their long-term survival: they must remain true to the ideals of their founding and remain relevant to the society that supports them (Ashby, 1966). This balancing act is complicated as institutions develop closer ties with society. Recent critiques fault higher education for lacking clarity of purpose or priorities and accuse universities of being confused regarding their intellectual identities (Bérubé & Nelson, 1995; Bloom, 1987; Lucas, 1998). While such criticisms are certainly not without merit, it may also be the case that higher education has reached the point where there can no longer be a single legitimating idea for the university. Delanty (2001a) argues that the modern university exists in a society in which knowledge exists outside the university and is no longer considered an end in itself, owing primarily to the pervasiveness of communications technology. People outside of the institution have access to information and knowledge that, in an earlier time, would have been contained only within universities for the use of selected elites. This requires a reevaluation of institutional purpose.

Under *functionalism*, tradition regards the university as a *cultural institution*, with different organizational forms used to meet whatever societal needs are expressed. The state is still a guarantor and protector, but also assumes a more active role in goal formulation and the support of specific functions to help the university

adapt as society becomes more complex. Regarding research, the state can act strategically to stimulate research through varying departments and organizational formats with a slightly more utilitarian outlook; knowledge for its own sake produces higher quality research which yields more applicable results than simple problem-oriented inquiries (Bleiklie, 1998).

As Kerr (2001) points out, while writers were idealizing the traditional university, it had in fact already evolved beyond that form, becoming more complex, assuming roles never before imagined. His concept of the multiversity contributed to our understanding of this complexity, as did his description of the federal grant university. Flexner (1930, 1994) wrote about universities as institutions pursuing knowledge and how their modern complexity, with departments and specialists, had rendered the vision of Newman an antiquated idea. However, his observations also contained criticisms of institutions such as Harvard that they were straying from what he considered the central idea of a university by having such schools as business, journalism, and other professional programs. Pelikan (1992) has challenged and updated Newman's philosophical basis for the university to include the advancement of knowledge through the sciences, on the principle that teaching and research could not be separate functions. Still, the university is a preserve of culture.

But this cultural role is said to be under assault by the political and economic forces leading universities toward market-oriented behavior. Readings (1996) declares that universities have lost their historical function of providing cultural unity as they are forced to focus on excellence, accountability, and increasing their own revenues. When

universities are viewed as social institutions (Gumport, 2000), their contributions to society are not measured in market terms and pure research is valued. The functionalist tradition is highly critical of what it sees as the corporatization of higher education.

The last tradition, *rationalism,* considers the university as a *corporate enterprise,* advocating a more centrally-planned and managed research program with a systematic exploitation of resources to serve society's social and economic needs. In this view, the spontaneity inherent in pure research is a waste of resources because it is unplanned; government acts on society's behalf to produce more coordination of research outcomes, thereby deemphasizing institutional autonomy (Bleiklie, 1998). The university has always been in a patron-client relationship, first with church, then with the state, now with industry, and has at critical junctures become the transformative element in society. The role of the university must be understood within the context of economic and social change writ large (Benjamin, 2003). Universities are uniquely positioned to participate in the postindustrial economy as they are in the business of creating and disseminating knowledge.

Although universities were founded on the academic principles of truth-seeking and knowledge creation, there has always been an interest on the part of the nation-state that universities should provide a benefit to society. As universities developed, there was a societal demand that they should extend the benefits of education to a wider proportion of the population, and use their research capability to solve social problems. The response of service established the idea that a university was not only responsible to its immediate surrounding area, but that it should extend its work to the

boundaries of the government that supported it (Hoeveler Jr., 1976, 1997). Since they were established by government, universities owed some measure of service to it and going forward, "the university carried with it two great forces: science and nationalism" (Kerr, 2001, p.9).

The rationalist perspective advocates that universities be responsible for quality, excellence, and efficiency (however those come to be defined in a particular system) and that institutions have obligations to external stakeholders to manage themselves in such a manner that they contribute to economic development (Bleiklie, 1998). This economic contribution is entrusted to institutions with an expectation that they will become more effective in achieving it (Alexander, 2000).

Understanding that these different visions for universities and academic science can coexist is critical for understanding the changing nature of faculty research work. As the processes of academic scientists become studied as social activities, we can see how new forms of science come into being that do not necessarily replace old ones.

The Transformation of Academic Science

The first step towards analyzing the transformation of academic science is to understand that academic scholarship itself has become more global (Ziman, 1996) as a result of the end of the Cold War and the continued internationalization of the academic profession (D. W. Cohen, 1997). Similar to the way in which global problems have arisen that are beyond the scope of any one nation to solve (Woods, 2000), Cohen makes the observation that academics have formed international communities of expertise with

one another and with non-academics to address these problems, and that these lead to new fields.

The global flow of knowledge also creates more competition for scholars in any given nation (Skolnikoff, 1994). While researchers in Western higher education systems typically have access to the work and findings of those around the world, scholars now increasingly have access to the science produced in those nations with advanced research programs. This asymmetry allows other nations to 'catch up' to the more advanced nations more quickly. The globalization of research is not about one idea of science, but rather, occurs through the interconnections among scholars in their own localities (Stichweh, 1996). The diffusion of knowledge through the differentiation of individual communities is the true cause of global science:

> The globalization of science is not the result of one scientific community of scientists with a shared set of normative and cognitive presuppositions emerging. Instead it is the incessant proliferation of ever-new communities of scientists with progressively restricted jurisdictions, which organizes the social and cognitive space in a way which is incompatible with the boundaries of national scientific communities (p. 332).

Universities participate in regional development through "the social context of innovation" (Mitra & Formica, 1997, p.10). Entrepreneurship and innovation emerge through a combination of collaboration, support from government, and various degrees of networking. For universities, becoming a network organization means first, forming relationships with industry, policymakers, funding providers, cultural organizations, and with the public at large, and second, participating in the formation of a regional research agenda (Goddard, 1999).

For individual faculty, being part of a network of scientists is increasingly seen as a legitimate part of their work. Faculty in the life sciences participate in networks with other academics and scientists from biotech firms, with the work organized around projects and the structure of the organization defined by the interactions and connections among those involved. The boundaries between formal organizations become permeable as persons form relationships, share information, and collaborate on projects. The academics involved come to accept this as a legitimate component of doing science (Smith-Doerr, 2005).

The traditional sociology of science has, perhaps, an idealized vision of the academic scientist. This notion of science is also bound up with the way innovation has been perceived in modern America. The traditional notion of innovation from universities is based on models of linear knowledge flows, with 'demand pull' or 'technology push' assumptions. This model has developed from the vision of Vannevar Bush regarding the relationship of science between basic science and technological innovation. Bush realized the commercial value of products created through university research (COGR, 2000; Guston & Keniston, 1994), and outlined his idea of academic technology transfer in a report entitled *Science: The Endless Frontier* (Bush, 1945). This process of technology transfer was built on a foundation of basic research, which is distinguished from applied research. Basic research is traditionally viewed as making problem solving possible as it leads to the development of sound theories (Kodama & Branscomb, 1999; Rosenstone, 2001), and being also called "pure" research, has

historically been seen as requiring freedom from external or financial interests (Etzkowitz & Leydesdorff, 2000a).

In the US, the research policy of the federal government following WWII had two primary elements. First, basic science would be supported without regard to practical ends. Thus, the federal government would support research in basic science in a decentralized manner, with federal agencies all supporting a proportionate share through competitive grants as reinvestment in the basic research which led to the technology the agencies needed. This was a "pipeline model" of science, in which it was assumed that the basic research funded would support a private competitive economy of firms investing in innovations and applied research that would benefit them (Branscomb & Keller, 1998; Bush, 1945; Geiger, 1993; Stokes, 1997).

The second element of the federal policy was that the technology created through the federal agencies would flow to industry through a "spinoff" process, which the government presumed would be automatic and cost-free. In this model, government, industry, and academia operate in separate spheres and do not share functions or have formal ties. Universities produce knowledge, disseminate it through publication, and transfer of knowledge and innovation is conducted through intermediaries (Branscomb & Florida, 1998).

Building on the notion that broader societal factors can influence the production of knowledge (Kuhn, 1962), new models for the transformation of academic science have been offered. One label for this literature is entrepreneurial, (Slaughter et al., 2004), as many authors discuss the manner in which universities will have to compete in

markets and find new ways to obtain funding and produce research. This label is only partially correct, however; entrepreneurialism is a term that effectively describes organizational responses to an altered research environment, but it does not capture the complex reality of the transformations to academic science in a global context. For that, models that address processes for producing knowledge must be considered. These perspectives resituate academic science within a global knowledge production process, and they can provide guidance for a modern sociology of science with associated norms for academic science. That distinction will be drawn blow.

Entrepreneurialism

Entrepreneurialism is viewed as a managerial response to an altered research environment. Typically, its purpose is to make higher education institutions more opportunistic and self-sustaining, causing them to be both fully engaged with and more responsible to society (Neave, 2000). This response is accompanied by new managerialism, a strategy applying management theories and techniques from the private sector to universities (Deem, 2001; Marginson & Considine, 2000). To those that favor the traditional view of a university, this represents the introduction of a corporate culture that will lead to the corruption of higher education (Giroux, 2001; Williams, 2001). Regarding academic science, entrepreneurialism does present the opportunity to mobilize the university's intellectual resources to benefit society, but also carries the risk that scholarly achievement will be measured only in financial terms, or that universities will compromise their independence (H.-D. Meyer, 2002; Soares & Amaral, 1999).

Proponents assert the entrepreneurial university is a new paradigm which complements the traditional mission of research by adding to it the importance of direct involvement in commercial development of research and a more proactive stance regarding regional development (Smilor, Dietrich, & Gibson, 1993). Through greater engagement, there is the potential for universities to meet the knowledge needs of a diverse array of publics. In this view, the work of the university is not diminished, but enriched through greater connections to diverse communities, producing, disseminating, and applying knowledge that contributes to the development of economies, peoples, and cultures (Walshok, 1995).

Although it can take many forms within universities, for the purposes of academic science, a concise summary of its forms was provided in a study of life scientists (Seashore-Louis, Blumenthal, Gluck, & Stoto, 1989). Five types of academic entrepreneurship were defined, presented in order of most to least consistent with traditional notions of academic science: 1) large-scale science, describing the reality that modern research involves big laboratories, operating multiple projects with large staffs; 2) supplemental income, inclusive of faculty consulting, extension services, and royalty income; 3) industrial support for university research, which, in addition to money, also includes large-scale joint ventures and other collaborations; 4) patenting results from research, and 5) direct commercial involvement, including formation and management of startup firms based on research results. Individual faculty can be involved in any or all of these activities simultaneously.

Entrepreneurialism has been studied at the university level, with the goal of determining effects on the organization of academic units and systems. In an important qualitative analysis, Clark (1998) studied how five universities became entrepreneurial and transformed how they organized research in an effort to recapture some of the autonomy lost from changing government support. The state of flux in which institutions find themselves is termed the "demand response-imbalance" (p. 129) because the demands on universities outpace their capacity to respond. Importantly, greater institutional advancement through innovative practices need not include any that are beyond the bounds of academic legitimacy in order to be effective.

The entrepreneurial university for Clark (1998) consists of five elements, three of which are relevant to the processes of academic science. The *expanded developmental periphery* comprises new units that reach out to external organizations. These outreach offices can work in technology transfer, industrial contracts, or intellectual property development. They can also be project-oriented research centers that work with one or more traditional academic departments to help outside agencies solve practical problems in social or economic development. The *diversified funding base* allows the institution to augment its declining support from national governments through competitive research grants, industrial contracts, local governments, and philanthropic foundations, as well as licensing and patent income from intellectual property. This allows the institution greater autonomy by increasing its discretionary income, thereby ensuring it is not dependent upon any one source. Finally, the *stimulated academic heartland* recognizes that traditional departments are still the workhorses of the

institutions and that the key to transformation is having them become innovative inasmuch as they are able, helping them find their own ways to generate new income. It becomes a blending of new values with old traditions (Clark, 1998).

One limitation of Clark's analysis is that his examples include primarily specialized and smaller institutions; in the analysis he notes that specialized institutions are better positioned to pursue entrepreneurial responses. It remains unclear whether and how comprehensive institutions can follow the pathways laid down by this research (Soares & Amaral, 1999). Deem (2001) is also critical of Clark for using only campus interviews and not engaging in a more layered case examination. She says this leaves some doubt about the claimed success of the university programs because there was no independent verification. However, the most important lesson to be gleaned from these case studies is that the universities all fashioned their own response to the demands they identified. Their responses were steeped in their mission and identity of their institution, and each institution responded differently.

Clark does not discuss processes for academic science specifically; he limits his analysis to the organization of and strategic options for research units. Even so, the outreach actions described in the case studies regarding these three pathways of transformation provide examples of the types of engagement with local and regional actors that universities can undertake to expand the reach of their research enterprise.

Entrepreneurialism has also been examined as a market-driven phenomenon, with the modifications to knowledge production depicted from the perspective of faculty by Slaughter & Leslie (1997) in their discussion of academic capitalism. They

employ resource dependency theory (see Bealing & Riordan, 1996; Hackett, 1990)—which suggests that institutions seek greater social legitimacy in the hope of attracting additional resources—to explain emerging incentives that affect university behavior. The theory is based on case studies of four nations: the US, UK, Canada, and Australia. Their conclusions are based in part, on historical accounts of the higher education policies in the four nations, including government expenditures on higher education, and policies directed towards science and technology. The authors conclude that the finance policies of block-grant reductions had the effect of inducing competitive behavior in institutions by forcing them to seek external funding, forcing institutions and faculty to enter a market. National R&D policies became science and technology policies, concerned with technoscience, emphasizing product innovation at the expense of basic research (Slaughter & Leslie, 1997).

Several items remain unsettled about the concept of academic capitalism. Deem (2001), while saying the institutional effects of resource dependency are convincing, is less persuaded by the claims that these policies are changing the values of individual faculty. She is critical of Slaughter and Leslie for making long-term policy claims using one set of interviews from faculty in only one of their four focus nations—Australia. Furthermore, the exclusive reliance on organizational theories such as resource dependency and isomorphism obscures other changes that are occurring via globalization. Slaughter & Leslie offer no recognition that processes of scholarship are changing in light of technological advances (Ziman, 1996)—as discussed earlier—or that

universities are themselves in competition for research monies and knowledge workers with other research entities in a regional or global environment (Nowotny et al., 2001).

In addition, their analysis that shifts in the global political economy are the result of neoliberal policies reveals that they are predisposed to reject theories of changes to knowledge production as causal factors. For example, there is no consideration of government as a partner in research—only as an adversary in budget deprivation. Finally, their stark criticism of entrepreneurialism focuses on technology transfer, but does not consider it as part of a larger regional development strategy in which universities participate as a centerpiece of innovation. And it is overstating reality to suggest that universities have become wholly defined by profit maximization, as academic capitalism suggests. Institutions have many other means for connecting with regional partners than simply patenting research findings; there are still many functions that universities perform which are not related to market activity such as academic training, consulting, and service (Smilor et al., 1993; Walshok, 1995).

Academic Science in the Global Context

Although the organizational models in the previous section provide some insight into organizational changes, they fail to provide a suitable representation of knowledge production in a global knowledge economy. They remain focused on universities in the context of national systems (Marginson & Rhoades, 2002) and consider globalization primarily as an economic phenomenon, restructuring state and national finances away from social programs and education. Importantly, they do not attend to the process of academic science nor do they consider the impacts globalization is having on other

contexts for knowledge production. The process models presented below are the best starting blocks for building a framework to represent the complete reality of university research in a global context.

Basic Science & Technological Innovation. One attempt to move the debate beyond the pipeline model or the clash between basic and applied research is Donald Stokes' (1997) theory on the relationship between basic science and technological innovation. Stokes contends that much of our modern science is based on a model concerned with both fundamental understanding and considerations for use, for which he uses Pasteur as one, but not the only example. Areas of science that bridge these purposes include microbiology and its study of disease, earth sciences and the quest to predict earthquakes, and economics and the goal of eliminating poverty. Scientists in these areas are invested in pure discovery of knowledge—not in spite of application—but because they are interested in some aspect of the natural world.

As an alternative to the linear model of science and development, Stokes (1997) asserts that fundamental scientific understanding and technological application will proceed as two loosely-coupled trajectories. This is because each can be advanced without intersecting the other, and that advancements in scientific knowledge or technical capacity can emerge as the trajectories influence one another. Thus, use-inspired basic research leads to technological innovation, with the reverse also true.

Triple-Helix Model. Another theory that attempts to explain the changes to science focuses on intersecting spheres of influence. It asserts that the public, private, and academic institutional spheres are increasingly working together through university-

industry-government alliances and other innovation partnerships to create intellectual property, and that the once-separate functions are now being shared by the others. Coordination of these complex activities requires a better technology policy, with input from the state as well as academics and industry leaders to create solutions for national or multinational innovation policies for the 21st century (Etzkowitz & Leydesdorff, 1997; Etzkowitz, Webster, & Healey, 1998a).

This model also critiques the linear, traditional model of innovation as having zero-sum-game assumptions that view transfer functions as detracting from the missions of the institutions to only produce basic knowledge. By contrast, the triple helix model recognizes overlaps between the institutional spheres; e.g., the securing of intellectual property by universities, while businesses identify research problems and disseminate knowledge. Rather than the "endless frontier" of basic research as its own end, innovation now occurs through an "endless transition" model linking science and utilization (Etzkowitz & Leydesdorff, 2000b). The flows of knowledge in these trilateral arrangements are not linear, but are suggested as spiral in nature, with reverse flows from industry to academia, with government serving as a strategic partner for both. As governments look to formulate local and regional development strategies, they look to the resources of academia and the potential of alliances with industry to stimulate wealth creation (Etzkowitz & Leydesdorff, 1997; Etzkowitz et al., 1998b).

The triple helix model is grounded in the capitalization of knowledge which, on an individual level, is similar to Slaughter & Leslie's (1997) notion of academic capitalism—translating intellectual assets into commercial property. However, the

model also has a societal level regarding the development of innovation policy and the utilization of these resources to stimulate growth and research. There is a recursive property to the model, in that the outcomes will be mutually reinforcing: universities spin off technology that produces revenues for firms, while the income universities receive helps support the research enterprise. The system ideally provides more support for basic research through the revenue generated (Etzkowitz & Leydesdorff, 1997; Etzkowitz et al., 1998b).

This last conclusion is regarded as an unfounded assumption by Slaughter & Rhoades (1996) who, based on their examination of political coalitions for support of research funding, fail to see these benefits. They see increased industry ties and government partnerships as undermining academic labor and university values, and they express hope that a social movement will someday counter, destabilize, or reshape the current technoscience regime.

The crafters of the triple helix theory rebut claims that the model steers universities away from the public interest and towards that of the market and industry. The involvement of government with industry and academia produces a "quasi-public sphere" (p. 150) situated between government and private interests to replace the public sphere that is shrinking in terms of direct support for universities. This helps correct for the corporatism that critics see emerging from industry alliances by making alliances more democratic as the government is involved to correct the market—steering institutions to research and industry to address problems that might not

receive attention under the prior model with separate spheres of influence (Etzkowitz & Leydesdorff, 1997).

Mode-2 Science. A third theoretical area—Mode-2 Science—concerns not just modifications of scientific processes but the transformations to knowledge production as a whole. The critical element for understanding Mode 1 v. Mode 2 knowledge is the concept of a socially distributed system of knowledge production. In this theory, globalization is drawing universities into a new system of knowledge production in which they will play a role very different than their traditional one. The development of this system has a supply element and a demand element (Gibbons, 1998).

On the supply side, the massification of higher education has created increasing numbers of educated people familiar with science and the methods for research—an international phenomenon that will not likely be reversed. Many of these people are themselves equipped with specialized knowledge and skills in the research and science professions, and are actively engaged in research-based activities, bringing their intellectual resources to bear on a wide-ranging spectrum of problems that are unlike the ones they encountered in their university training. The massification and internationalization of higher education means that there is an increasing number of places where research is performed, with a growing portion of it taking place outside of universities, in government labs, independent think-tanks, etc. The irony of this for universities is that as higher education continues to educate people, it undermines its own monopoly on knowledge production (Gibbons, 1998; Gibbons et al., 1994).

Regarding the demand side, the need for firms to acquire specialized knowledge for the identification and solution of problems has led to the rise of the network firm with flexible and adaptive structures, and the proliferation of alliances, partnerships, and collaborations with universities. Specialized knowledge is viewed as a continuously replenishable resource, unlike labor or capital, but is difficult for firms to capture in-house. The competitive pressure for these firms to innovate creates the continual demand for knowledge (Gibbons, 1998; Gibbons et al., 1994).

The ongoing expansion of knowledge producers on the supply side and the continual demand for specialized knowledge on the demand side creates a socially distributed system of knowledge production. This distribution is assisted by global communications, helping to foster interconnectedness among a growing number of sites of knowledge creation. This makes distributed knowledge production both cause and consumer of innovations that enable global information transmission (Gibbons, 1998; Gibbons et al., 1994).

In Mode 1 knowledge production—typically associated with conventional academic models of discipline-based research—problems are identified and solved according to the norms, values, and methods of the academic community. The process of knowledge production is primarily discipline-based, in terms of organizational structures and the frameworks utilized. Also, there are limited options for quality control, usually occurring through peer review. In Mode 1, the university is viewed as the primary, if not only, producer of knowledge, and academic careers are the only option for knowledge producers. Finally, the idea of individual creativity and the image

of the lone investigator persist, no matter how far removed they may be from the reality of modern research (Gibbons et al., 1994; Jacob, 2000).

In Mode 2, knowledge is said to be produced in the context of application. This means that the knowledge is intended to be useful to someone and that those people are involved in negotiations regarding the research from the beginning. Application, in this sense, means more than commercial product development and taking innovations to the market place. It is about solving practical social, scientific, environmental, and political problems. Thus, involvement could include conducting a project according to specifications of the user, or it could mean having the users, beneficiaries, and stakeholders integrated into the project (Gibbons et al., 1994; Jacob, 2000).

A more controversial aspect of Mode 2 science is transdisciplinarity. Gibbons et al. contend that inquiry in Mode 2 is not performed according to the norms of any one discipline, but that it emerges out of the application and the disciplinary perspectives of those involved and thus may not resemble any one or a combination of disciplinary norms. Also, this process is dynamic, so theoretical structures and research methods used in one application may or may not be used again (Gibbons et al., 1994). The extent to which uniquely novel methods and norms are created vs. adapted from existing ones is called into question by Jacob (2000). Also, in Mode 2, quality control can come from peer review, but also comes from social acceptability, cost effectiveness, and market competitiveness. Finally, Mode 2 recognizes that universities no longer have a monopoly on research and that the networks of communications held by researchers

are important sources of knowledge. It is these networks that come together to create research teams that solve problems, not institutions.

Mode 2 Science is not without criticism and has proved difficult to study empirically. Delanty (2001) does not view Mode 2 as making science more socially accountable because of the intrusion of the market into research that it allows. Rather than blurring boundaries between disciplines, it could be seen as blurring the boundaries between science and industry. He also feels that the notion of Mode 1 science presents a view of the university that is too simplistic and too stereotypical. On this last account he is probably correct, but since the concept of Mode 1 and 2 science is a thought experiment more than it is an empirically-grounded model, its value lies in what it tells us about emergent processes for research rather than current ones.

Following up on their concepts of Mode 1 and Mode 2 science, Nowotny et al. (2001) address the concept of social accountability. They argue that the new mode of knowledge production does not mean that science will proceed in a predetermined manner or that its methods will be uniform. They contend that science is becoming contextualized as it is more integrated in society. This linkage is characterized by the development of complexity and uncertainty in society—what they term "Mode 2 society" (p. 11, 245). In this society, there are not only more participants but greater opportunities and means for communication between them. This breaking down of boundaries produces knowledge that is more socially robust. Rather than being completely internally-directed by academics, industry, or government, the engagement by multiple groups in negotiation allows the social context to become incorporated into

the research process. The continuous dialogue between participants allows for more openness in identifying problems, conducting research, and assuring quality.

Summary

In concluding their study on changing and permeable faculty boundaries in research, Slaughter, Archerd, & Campbell (2004) state "The status and prestige system that sustained the Merton/Bush model depended to some degree on the relative organizational autonomy of universities and science" (p. 162). An updated understanding of academic science highlights several important ways this situation has changed. Matters of causality are in dispute, with government resource restrictions and emphasis on intellectual property often cited, as is the globalization of scholarship and the potential for collaborations. However, the idea of socially distributed knowledge is critical and not sufficiently discussed in higher education circles; universities are no longer the only source of knowledge creation, and more aspects of society have demands for knowledge that has uses for problem solving and practical applications.

In this environment, many organizations are involved with academia in knowledge production, and universities forge relationships with governments, industry, and other seekers and users of knowledge. Actors, including faculty, become part of the social relations of knowledge production and thus, while boundaries of the past become less fixed, faculty acquire some degree of social agency to create new ways of conducting research. Concurrently, partners in that research have specific needs and uses for knowledge, and thus forge mutually beneficial relationships. Each can participate by contributing topics, methods, or utilizing findings. The potential for this

construction of new modes of academic science is not fully understood; what we see in the meantime are the effects that this transition is having on the traditional work of faculty.

Effects on University Faculty

General Effects on Values

The contention that involvement in commercialization will compromise universities is grounded in a discussion of the two distinct cultures present within academia and industry (Bok, 2003; Rosenstone, 2001; Washburn, 2005). Industrial and academic research has fundamentally different goals. Industry seeks to convert new technologies and research results into some form of economic advantage over rivals. There are disincentives to sharing this knowledge before it is developed, thus the need for secrecy and patenting innovations. In the view of academic science, secrecy and withholding knowledge are contrary to the mission of disseminating knowledge. Faculty seek recognition through publication, and universities reward faculty with tenure and promotion for their scholarship (Geiger, 2004). To use the language of Merton, research in industry violates the norms of communality and disinterestedness at a minimum.

As this study focuses on faculty, the effects of commercial involvement at the university level and by individual faculty require attention. A focus on the micro level of individual departments and faculty is particularly important (Laukkanen, 2003; Tuunainen, 2006), especially since the stresses and pressures created by the environment are felt at that level (Levin, 2006; Ylijoki, 2005). In the literature, the

findings are mixed on specifics such as faculty beliefs and altered research agendas. A common thread identified (Slaughter et al., 2004) in many empirical studies is that the effects of commercialization are concentrated in a few disciplines, and alters values to only a modest degree. For example, a recent review of the literature indicated that the effects of industrial collaborations are felt primarily by the involved faculty (Anderson, 2001). Seeking to dispel some prevailing myths about the subjugation of academic values to corporate ones in her literature analysis of university-industry relations, Anderson finds that industry partnerships are still largely concentrated in the sciences, and even then within particular departments or laboratories in some universities. Faculty outside those areas do not have a true picture of the benefits and costs of such ties.

Such findings are supported by other empirical research. A study of faculty in the sciences in North Carolina found that entrepreneurial activities were undertaken by small percentages of faculty, and that most faculty did not anticipate altering their relationship with their institution. The study attributed this finding to the differences in work values present in academia vs. commerce (Bird & Allen, 1989). Other research of life sciences faculty suggests that they are entrepreneurial at a modest pace, and that a small minority is actively engaged in this activity, but that no evidence indicates that such scholars are taking over academia (Seashore-Louis et al., 1989). More recent studies have also confirmed that faculty participating in collaborations have different views on such collaborations than do non-involved faculty and that such faculty are

more willing to tolerate ambiguity and negotiate potential conflicts of interest (Campbell, 1997; Campbell & Slaughter, 1999).

Additional support of this conclusion comes from Ylijoki (2003) in her results from a case study of three academic units in three universities in Finland. Based solely on interviews, the study reveals that striking a balance between academic capitalism and traditional research is a reality in all departments, but that this balance takes differing forms depending on how close a department is to the market. However, the author found no evidence to conclude that academic capitalism was displacing the traditional values and activities of the departments. Faculty, it seems, are very resilient in the face of a changing academic funding and labor process.

One explanation for this could be the effect that increased university ties with industry has had on reshaping academic career paths. The plethora of research centers that collaborate with industry that have sprung up since 1980 have made moving between academia and industry more commonplace (Dietz & Bozeman, 2005). A study of the CVs of faculty in research centers with industrial ties found that nearly one in six jobs and nearly one in eight of their total career years had been spent in industry. Moreover, 20 percent took their first academic job five or more years into their career, belying the notion that beginning in industry forecloses academic career options. There are patterns quite different from the academics of even a decade ago. Particularly for faculty associated with university research centers, there is a greater likelihood that they have started or held positions within industry prior to becoming academics. The

creation of research centers with industry ties by governments since the 1980s has allowed faculty to have careers in each arena.

Evidence exists for differentiation in the way faculty approach commercial activity. Meyer (2003) distinguishes between entrepreneurial academics and academic entrepreneurs. The former may not necessarily be interested in working with a spin-off company full-time in the pursuit of growth and market share, as they typically may be more interested in science questions rather than business issues. The latter is interested in business formation, including networking, developing leadership, and securing funding from non-research sources.

Proponents of academic capitalism identify institutional changes at the level of faculty labor, and in their research activities, in particular. Academic capitalism is the engagement in market (for-profit) and market-like (competition for external funds) activity on the part of institutions and faculty to secure external funding. In this view, the need for private innovation has altered faculty research, pushing it towards the market, while the reduction of resources from the state has forced institutions to restructure their organizations and seek money in other forms, especially for research. What a university has that facilitates resource generation is the knowledge possessed by its faculty. Institutions and faculty increase revenues by competing for funds in sponsored research, thereby engaging in academic capitalism (Slaughter & Leslie, 1997).

One study of the alterations to faculty careers attempted to theorize how faculty balance tensions between academic and commercial roles (Owen-Smith & Powell, 2001). In a qualitative study based on more than 80 interviews with prominent life

sciences faculty, the authors examine the effects the transformations in academic science are having on faculty careers. Their solution is based on the idea that it would be impossible to capture the complex array of positions that faculty occupy in a simple dichotomy—thus, they propose a four-category typology inclusive of hybrid types that share properties of the main types.

The typology, shown in Figure 1 below, is based on comparisons along two dimensions: 1) whether the commercialization of research threatens or complements the academy and 2) whether academic and commercial science overlap or constitute distinct realms. The resulting four positions represent two main positions, and two hybrid positions.

The positions on the main diagonal represent the primary dichotomy as discussed in the debate over the changing nature of academic science. The "Old School (OS)" is characterized by beliefs that academic and commercial science are distinct areas and that the latter threatens the academic ideal of research. This traditional viewpoint can be characterized by Merton's ([1942] 1973) norms of science: 1) Universalism, 2) Communality, 3) Disinteredness, and 4) Organized skepticism. Such faculty do not pursue patents or start-up firms (Owen-Smith & Powell, 2001).

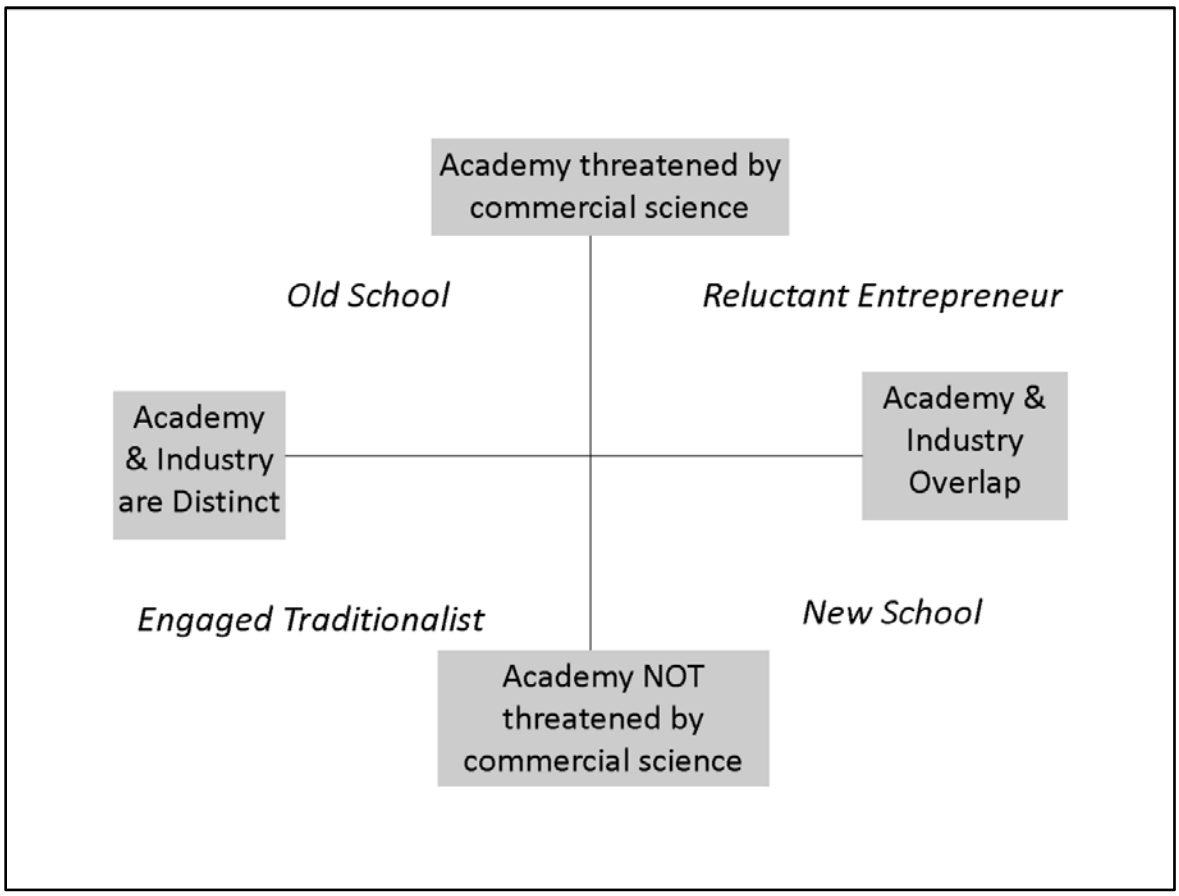

Figure 1: Typology of Faculty Positions

Note: Adapted from Owen-Smith & Powell, 2001.

Opposing that viewpoint is the "New School (NS)", which accepts the convergence of academic and commercial science and views them as complementary processes. For these faculty, both types of research are seen as interdependent as each leads to success in the other. Successful science requires collaborations across academic and industrial locations and resources, with a focus on discovery of innovations that solve real-world problems. Such faculty would have multiple patents, would be involved in translational research for start-up firms based on that technology, and could serve as technical adviser to such firms, all while retaining their university position (Owen-Smith & Powell, 2001). This viewpoint would be the most in-line with

the values associated with the transformed nature of science put forth in the triple-helix and Mode 2 theories of science (Etzkowitz et al., 1998b; Gibbons, 1995).

The off-diagonal represents two hybrid positions that share elements of both the new school and old school types. Because these positions straddle the conflict between the extremes, faculty experience tension in trying to resolve challenges and develop responses to issues that arise. Their negotiations between the two worlds depend on situational and individual logics. Those labeled "Reluctant Entrepreneurs (RE)" believe that commercialized science threatens the traditional notion of the academy, while also recognizing the overlap between the two realms of science. They adopt a pragmatic view that their best defense against the encroachment of commercial interests on the university and their research is to patent their findings through their universities. Still, the idea of generating spin-off companies from these patents seems inconsistent with their duties. Entrepreneurialism is viewed simply as a means through which their autonomy and the traditional norms of the academy can be preserved (Owen-Smith & Powell, 2001).

The other hybrid position "Engaged Traditionalist (ET)" holds that academia and commercial science are distinct realms, but the two types of ventures can be pursued by the same individual without danger of threat to the academy. These faculty believe their personal commitment to the traditional values of academia will enable them to pursue commercial ventures (and incentives) without compromise. They can be seen as successful academics that also disclose inventions, hold patents, and consult with startups (Owen-Smith & Powell, 2001).

This typology proposes values associated with each type in terms of what the faculty so-labeled believe to be true or acceptable in the practice of academic science or university research generally. However, the typology has not been tested and the type constructs have not been applied to real populations of faculty to determine how robust the theory is. For that reason, this study adapts the typology and operationalizes the constructs in a manner that allows for testing of them as a classification scheme.

Influence on Research Agendas

Empirical studies of faculty concerning the potential for commercial opportunities to influence their status as scientific investigators is not plentiful, but there has been some research in this area. The locus of control over faculty research was the focus of an extensive literature review analyzing changes in the university-environment relationship (Anderson & Seashore-Louis, 1991). The authors outline a trend away from self-regulation by faculty towards influence by many groups, caused by the shifts towards large-scale science, faculty consulting, the growth of industrial research, and increased regulation by the federal and state governments of research activity. Rather than having unlimited freedom to direct their own research programs, individual faculty are subject to a set of influences from groups external to the university. The broader research community now includes disciplinary and professional associations, which set standards for accepted practice, as well as scientific advisory boards, that may have the ironic effect of constraining individual academic freedom by limiting approval for research in new paradigms (Anderson & Seashore-Louis, 1991).

Governments influence the locus of control through the decisions of funding agencies to awards grant monies, and legislative or administrative initiatives to either direct funding towards certain areas, restrict communication between scientists, or limit who can receive funding. Industry has influence because of the access it provides to research funding, but value discrepancies with academia can cause problems for faculty. Finally, interest groups and other organized constituencies seek to influence research agendas through pressure on policy groups, universities, and occasionally, individual scientists. In the end, the many ways these external bodies influence research has made the relationships between faculty and institutions and between universities and the public so complex that the traditional norms for faculty autonomy and self-regulation are rendered less applicable (Anderson & Seashore-Louis, 1991).

Certainly, faculty have long been aware that they do not have unfettered autonomy to select research topics. A study of faculty in three science disciplines nearly three decades ago found high percentages of respondents indicating the principle of autonomy no longer applied to problem selection (Fishman, 1978). Considerations like disciplinary boundaries and peer evaluation were cited by 70 % of faculty as limiting factors, while the top three sources of limitations were reported as military institutions, government agencies, and corporate sponsors.

A qualitative study of faculty at seven community colleges found that faculty perceived their administrations and state governments to be pushing the colleges towards economic and business-oriented goals to gain favor with industry. These faculty perceived a threat to their autonomy and a sense that their values were in

conflict with those of the institution (Levin, 2006). Participants in another study indicated that their "research topics are selected to meet the preferences and needs of external financiers" (Ylijoki, 2005, p. 564), but since it was a qualitative study focused on personal and collective narratives, there was no additional details provided about any particular instances of external influence over topic selection.

The claim that industry sponsorship undermines academic freedom was not supported in a study of graduate students from engineering departments at six US universities. Students rated the relative influence of different actors (themselves, faculty advisor, other committee members, and the research sponsor) in three areas of their research experience (direction/emphasis of the research, methods, and interpretation of results. Across all three aspects of their research, students indicated they themselves had the most influence, followed by faculty and committee members, with sponsors generally having the least influence. The only significant differences were between students with university sponsorship and those with industry sponsorship on one item: those sponsored by university funds reported less influence from their sponsor (Behrens & Gray, 2001).

Blumenthal et al (1996) performed a comparison of respondents from two surveys conducted 10 years apart of faculty in non-clinical life science disciplines (see Blumenthal, Gluck, Seashore-Louis, Stoto, & Wise, 1986) to determine the effect of industry funding on topic choice. The populations were similar with respect to the issue. In 1985, 30% of those with such support and 7% of those without indicated that their topics had been influenced to some extent or a great extent by the potential for

commercial applications. In the 1995 sample, these values were 30% and 14%, respectively.

A small-scale qualitative study in Finland yielded mixed results on the tensions faculty perceived from university-based commercial involvement. While the faculty were aware of the potential for challenges to scientific neutrality, the subjects views differed as to whether the research format was always structured by the sponsor versus having some degrees of freedom to study questions of interest to the academic unit. Although the faculty in this study did not indicate outright opposition to corporate partnerships, they did object to a mixing of roles in which academic and private goals were integrated (Laukkanen, 2003).

The difference between being bought by industry or selling to industry may depend on how dependent each individual faculty member is on industry funding for the continuation of their research. In a study of clinical and non-clinical faculty, clinical faculty, who most often engage in research having commercial potential at the later stages of entrepreneurial activity—such as the development of product, devices, or procedures through trials—were more likely than non-clinical faculty to indicate that their choice of topics was affected by the commercial potential of the results. The distinction between the types of research these faculty conduct may mean that clinical faculty can be co-opted by industry while non-clinical faculty could be persuaded to sell their ideas to move them closer to commercialization (Seashore-Louis, Jones, Anderson, Blumenthal, & Campbell, 2001).

At the departmental level in universities, academics try to balance their university activities with private commercial development, as their work entails theoretical, experimental, and applied components. Still, faculty achieve this balance within the current university structure, making it more permanent than either advocates for change or traditionalists would have us believe (Tuunainen, 2006). Renault (2006) based the first proposition in her study on the notion that even within the norms and informal rules of the university, faculty have choices over whether or not to collaborate with industry, how to evaluate funding opportunities, and whether or not to publish results.

Common Issues

There are several issues that recur in the debate concerning academic and commercial science which are important because they cut across much of the literature and address topics of concern. These issues are 1) the debate concerning basic and applied research, 2) sources of funding and the effects of government/public agency grants vs. private contracts with industry; 3) Publishing and patenting, including restrictions on publication and matters of intellectual property; 4) Conflicts of interest or commitment; and 5) Criteria for success and what methods are generally accepted to indicate quality science and success as a researcher.

Basic v. Applied Science

The notion of "pure science" is long-established among academics. In an address to the American Association for the Advancement of Science more than 120 years ago,

Henry Rowland (1883) called for the concentration of science resources in only the most prestigious universities in the country, while insisting that any work concerned with application or invention had no place in the realm of pure science. Writers in the middle of the previous century also discussed this prevailing sentiment regarding basic or pure science; society was criticized for valuing "inventors"—as applied scientists were labeled—more than scientists (Conant, 1952).

Research in the sciences has surveyed firms about collaboration and the potential problems for universities (Blumenthal, Gluck, Seashore-Louis, & Wise, 1986), and used qualitative techniques to conclude that the boundaries between university and industry—or even between basic and applied research—are being redrawn by the faculty involved in this work (Slaughter et al., 2004). Faculty in that study discussed how the traditional distinctions are no longer as relevant; what is more important now was that the topic is interesting, and there is a greater understanding that basic research could be recast as applied or entrepreneurial, which is also attractive. The wall between basic and applied research is being torn down.

A recent qualitative study examined the cultural narratives senior researchers in three academic departments associated with academia in light of macro-level changes in higher education in Finland. Subjects expressed 'academic nostalgia" in the view of the author, manifested as a collective yearning for academic freedom and autonomy. For instance, those faculty in a high-tech department expressed loss regarding an unspecified earlier time that allowed them to conduct more basic research and have greater collegial relations with other scholars on campus. Researchers in an applied

setting discussed how they were formerly able to combine personal academic pursuits with those of their financiers, which the schedules and requirements of externally-funded research now prohibit. The author concludes this collective nostalgia is evocative of core values in conflict with a more diversified type of academic work that requires new skills such as management and networking, thus causing researchers to experience an identity crisis (Ylijoki, 2005).

Funding

The issue of research funding presents problems for academic science. Almost a half-century ago, Barzun (1959 [2002]) decried the involvement of philanthropic organizations seeking to donate money to universities. The problem, he contends, is the funds are encumbered for specific projects as identified by the giver, and are not provided to the institution. The outcome of this is that universities tend to value the attraction of money for projects, and the science produced may be of value only to the foundations providing the funds, and not society as a whole. Moreover, this causes a drive toward homogeneity of research, as "projectism" tends to demand research that is "in line with current programs" and "widely acceptable" (p. 189).

Funding agencies were cited by over 90 % of the faculty in Fishman's (1978) study as a source of limitation on faculty autonomy regarding selection of research problems. Having external reviewers and boards evaluate the importance of one's work for financial support reflects the reality of increased competition and the high cost of conducting science. Still, these faculty accepted it as part of the environment. Indeed, the problems imposed by the acceptance of external funds causes a dilemma for

universities. While the funds are needed to support many essential activities, the acceptance of them for specific purposes like economic development may threaten academic integrity and scientific norms (Geiger, 2004; Stein, 2004). Part of this concern stems from what type of research is done by faculty getting funding from different sources. Faculty who have spent substantial percentages of their career in industry secure more funding from industry and have greater rates of patent activity than those who have not, and more commercial activity overall, although their publishing activity is less (Dietz & Bozeman, 2005; Gluck, Blumenthal, & Stoto, 1987).

One of the few studies to use survey data presents mixed findings. Highlighting perhaps the blending of basic and applied research, a recent study in Norway found significant relationships between faculty stating they received industry funding and claims that their work was applied. However, faculty with industry funding also claimed to a greater extent that their contract research brought them new and interesting research topics and were less concerned about threats to autonomy than faculty with no external or industry funding. The authors also concluded there were no significant associations between commercial outputs like patenting or spin offs and academic publishing (Gulbrandsen & Semby, 2005).

Formerly, the type of funding obtained was indicative of the type of research being conducted, with a definite hierarchy in place; the collapsing boundaries of academic science may also be placing this hierarchy in doubt. Faculty involved in entrepreneurial science recognize that the distinctions between government grant support and corporate sponsorship as an indicator of pure science or greater value is

becoming less clear. The notion of "grantsmanship" has come to mean supporting the research, regardless of whether that is with government agency funds, corporate contracts, or other monies. Faculty can gladly accept industry funds if an entrepreneurial approach to their topic affords them the opportunity to advance interesting research.

Patenting/Publishing

Many of the debates regarding this issue center on the effects of the value differences between industry and academia discussed earlier. Discussions of shifting boundaries and ethical dilemmas involving restrictions on publication are common, and while faculty are moving away from traditional positions concerning issues of secrecy, access, and intellectual property, the difficulties suggest that faculty still have concerns to address (Slaughter et al., 2004).

Typically, the turning point in industry relations is the Bayh-Dole Act of 1980, the long-term effects of which are in dispute. Recent examinations of American universities patenting and licensing activity since the Bayh-Dole Act concluded that little evidence exits of any significant shifts away from fundamental research toward that which might be more easily patentable (Mowery, Nelson, Sampat, & Ziedonis, 2004). Moreover, the fact that the activity has been concentrated in a few disciplines means that any effect would be narrow in scope.

However, other recent work (Washburn, 2005) documents specific problems that have occurred at many universities, particularly in the fields of medicine and pharmaceuticals. The author concludes that many aspects of the Act were not based on

evidence of how academic science leads to innovations, and that universities are actually inhibiting science by applying for overly-broad patents that protect not just inventions but entire scientific processes, datasets, and fields of inquiry. She recommends revision of the Act and greater federal oversight and regulation of patenting.

In a survey of 2052 clinical and non-clinical life science faculty, Blumenthal et al found that those faculty with industry support had more recent publications, were more involved in administrative/service activities in their departments, and were more commercially active. However, the amount of industry funding faculty received was a critical factor. Those with more than two-thirds of their support from industry had lower numbers of publications, less service activity, and less publication influence than those with moderate or low levels of industry funding (Blumenthal, Campbell, Causino, & Seashore-Louis, 1996). Entrepreneurial activity has a positive influence on publishing, but does not appear to affect teaching or service (Seashore-Louis et al., 2001).

Still, faculty substantially involved in sponsored research activity with industry have been shown not to profess goals for their academic careers different from colleagues that are not so engaged (Allen & Norling, 1991). Items such as publishing, advancing pure knowledge, and problem solving were similarly ranked as most relevant across faculty types, while items such as establishing a firm, increasing personal income, and applying knowledge for social benefit were consistently ranked as irrelevant to their academic values.

Evidence from a study in Belgium (Van Looy, Ranga, Callaert, Debackere, & Zimmermann, 2003) suggests that entrepreneurial activity and scientific performance in academia do not hinder one another. Although this was a study at one university, it does sample faculty in 14 departments across the disciplinary spectrum. The authors found that faculty engaged in contract research did not publish at any significantly different levels from those not conducting such research. Furthermore, faculty conducting contract work did have more publications concerning applied technology, but did not have significantly fewer publications of a basic science nature. Thus, their increase in applied publications does not come at the expense of basic science publications. Also, as the total number of publications is higher overall for those faculty in contract research, there is a compounded Matthew effect.

Conflicts of Interest/Commitment

Regarding potential conflicts of interest and commitment, the financial ties faculty have with sponsors of their research are certainly of much scholarly interest. Washburn (2005) concludes that there are too many cases of faculty having stakes in their own companies or those companies providing them with funding to let the practice continue. Certainly, this can place faculty in multiple roles simultaneously, forcing them to create new strategies to juggle their responsibilities and obligations (Slaughter et al., 2004).

The policy incentives offered by universities can influence the decisions of faculty to disclose inventions and pursue patents. In some cases, review of financial ties required additional management steps by institutional advisory boards (Boyd & Bero,

2000). However, some research indicates that individual beliefs are still the most important factor. Conflicts of interest and commitment inhibit faculty from engaging in more entrepreneurial activity, but university tenure and promotion policies that fail to give sufficient consideration to disclosures and spin-off formation produce greater restrictions. In a mixed-methods study of faculty across university types, age, and disciplines, Renault (2006) found that individual beliefs about the role of universities partnering with industry to commercialize technology were the single largest predictor of their actual behavior in collaborating with industry, patenting findings, and establishing a spinoff company. Personal beliefs were more important than university policies regarding technology transfer such as revenue sharing, or demographics such as the age of the faculty member. Moreover, although the beliefs were self-reported, subjects claimed that their personal beliefs were consistent over the course of their career, having been formed in graduate school.

Allen and Norling (1991) conducted a survey of 398 faculty from forty four-year institutions in Pennsylvania. Their goal was to determine whether faculty involvement with industry compromised institutional priorities, teaching and service, or created a desire for faculty to leave their institution. Their study found little difference in involvement in important campus activities such as teaching and service between faculty types. Even faculty who were "supercommercial"—that is, involved in client-based research, consulting, and start-ups—tended to devote similar amounts of time to such activities relative to their colleagues not so involved.

Asserting that academics who engage in industry opportunities such as entrepreneurship and spin off companies do so in search of profits is too simplistic. Returning to Meyer's (2003) contention that there is a difference between entrepreneurial academics and academic entrepreneurs, the former are not classic entrepreneurs and thus are not typically growth-oriented or focused primarily on the business side of their venture. Two of four cases studied in the US and Europe exhibited this slow-growth, research-based orientation by surviving primarily on public research grants in business incubators while their founders continued to work in universities. The spin offs also failed to accomplish necessary business tasks like creating a board, accessing business development funds, or establishing networks of business partners. There are thus academics who form spin offs with the primary motive of utilizing results to raise funds for continued research (M. Meyer, 2003).

A survey of graduate students and post-doctoral fellows (Gluck, et al) revealed that participants believed benefits from industry support outweighed potential problems, but evidence of noteworthy risks was found. Direct industry support was associated with fewer publications, constraints on discussing research results, as well as expectations of service to a sponsors' industry as a condition for funding (Gluck et al., 1987).

Criteria for Success

This item is included primarily because of the discussion in the entrepreneurial science literature about the changing criteria for evaluating what counts as good science. Traditionally, quality comes through peer review by fellow specialists in one's

discipline conducted according to the accepted paradigms, theories, practices, and methods used in a given specialization (Ziman, 1996). In addition to peer review, models like Mode 2 science introduce the concept of social accountability, in which the science is also evaluated for its effectiveness, competitiveness, and social acceptability. Since the research is conducted by or in affiliation to a network of social actors involved in identification of problems, setting of research priorities, and interpretation and diffusion of results, quality control is also conducted according to criteria important to these groups (Gibbons et al., 1994; Nowotny et al., 2001).

Summary

The challenges presented to faculty by the transformation of academic science underscore the shortcomings of the traditional normative structure of science. Whereas before, as shown in this study, the norms were violated, ignored, or even challenged, the new organizational realities of academic science are making them less and less relevant to the daily work of faculty, even as an ideal. The effects described above outline the transitional nature of the current practice of academic science, and how faculty are having to invent innovative ways of doing their work, as they seek to straddle areas previously thought to be incompatible. The creation of new strategies for practice despite organizational inertia of tradition leads to a consideration of how change can occur in the face of such substantial resistance. The following section begins this discussion.

Institutionalism

The contention within the higher education literature that academic science is being pulled in a direction that is challenging to—or even inconsistent with—what academic research scientists should be doing seems based on the premise that the traditional model of research (basic v. applied, linear dissemination of innovation) is an ideal not to be challenged. While there is some historical debate regarding the original nature of university research (Etzkowitz & Leydesdorff, 2000a; Newfield, 2003), the conventional model is firmly entrenched as the baseline (Benner & Sandstrom, 2000; Bok, 2003; Buchbinder, 1993; Shils, 1997b). Part of the analysis required is to determine whether faculty values and research practices are consistent with the traditional model or whether they indicate divergence. Evidence of divergence could indicate the existence of different institutional logics concerning academic science. This requires a brief review of institutionalism, in particular how the theory explains deviations from established patterns of activity.

Intellectual Foundations

A classic problem in sociological inquiry is the emergence of social order, or the question of why society is generally structured, predictable, and exhibits shared patterns of behavior. Social order is generally viewed as a stable system of social structures and practices which are shared by society and define norms for behavior (Hechter & Horne, 2003). Institutions, as understood in social science, emerge from this tradition; social institutions are viewed as one of the vehicles by which society becomes

ordered (J. H. Turner, 1997). Institutionalism is a concept studied across the social sciences (W. R. Scott, 2001), particularly of late in economics, political science and sociology (Hall & Taylor, 1996).

The concept of institutions in social science is a qualitatively different construct than the common use of "institution," as being synonymous with organization"(Selznick, 1996). Whereas that term refers to real, formal organizations such as businesses, groups, and schools, the study of institutions in the social sciences is concerned with the abstract nature of social order. Organizations are collective entities having an internal structure, but can also be subject to institutional constraint or an institutional framework that governs the interactions of those comprising the organization (Knight, 1992). Institutionalization is the process whereby social practices become sufficiently regular and continuous to be considered as institutions (Eisenstadt, 1968a, 1968b).

Theorizing and research on institutions has a long intellectual history with foundations in many lines of scholarship (Koelbe, 1995; W. R. Scott, 2001). The tradition as developed in sociology is of most interest for this research, as it deals with the norms and values embedded in social structures. Explanations for the perpetuation and stability of institutions are rooted in classical accounts of the social order. Social philosophers such as Comte, Spencer, and Rosseau asserted that social phenomena must be studied as givens, with external, observable properties similar to natural phenomena (Giddens, 1972; Knight, 1992). Building on this, Durkheim (1895) believed that analysis of the social order could not begin with studies of individual actors, but instead rested upon structures he called "social facts," or facts in nature. These are the

building blocks of society that become manifested in social forces which persist beyond and across individuals because of their obligatory and coercive properties (Giddens, 1972; Nee, 1998). These properties are observable due to sanctions imposed upon individuals for violating social facts, such as moral obligations.

Another important foundation of social institutions is the concept of *legitimacy* established by Weber. Social order is possible, in the theoretical tradition of Hobbes, because individuals agree to transfer certain rights and liberties to the state in return for guarantees of safety and protection. Weber was concerned with how a state could maintain order since it could not be done with only policies (Hechter, Friedman, & Kanazawa, 2003). Weber wrote extensively about what made it possible for human beings to accept the authority of other human beings to rule over them. His answer lay in the concept of legitimation (Lassman, 2000). Legitimacy refers to whether people, collectively, accept a particular social order or set of rules as valid. The legitimacy exists in the abstract, separate and apart the performance of the entity under consideration. For example, the idea of a government must be accepted before any particular government can come to power. Legitimacy is also important because it removes authority and validity from individuals and places it in the rule of law, procedures, and societal expectations (Lassman, 2000; Scaff, 2000). Weber's prime example of this manifested in institutions is bureaucracy, a social system distributing power based on hierarchy and positions, in which interactions between individuals are governed by rules, and which produces action through individuals performing accepted roles.

Bureaucracy as an economic institution transformed the way society performs work (Swedberg, 1998).

Evolving Views of Stability

The study of institutions in social science has generally been concerned with two fundamental issues: seeking explanations for the similarity and persistence of institutions, while more recent scholarship has sought to understand the mechanisms producing institutional divergence. The line of inquiry traditionally undertaken in theorizing and analysis seeks to explain the similarity and persistence of social practices, structures, and organizations across time and space. Early writings on institutions actually predate the study of organizations, as the early scholars did not study organizations, theorizing instead from considerations of broad social system or local interactions (W. R. Scott, 2001). Also, this scholarship sought to understand the collective nature of institutions and how they represent something beyond individual actions. Economists such as Thorstein Veblen understood that individual actions were motivated by habits and relationships with others. He also saw that these motivations had some degree of permanence when he noted that institutions were "settled habits of thought common to the generality of man" (Veblen, 1919, p. 239).

Hughes (1936) referred to institutions as social phenomena that established collective behavior, had observable focal points of activity, and achieved relative permanence through setting and satisfying social expectations. Also in the 1930s, Talcott Parsons saw the need for a social theory of institutions as critical; he conceived of institutions as comprised of norms and values commonly held among people. He also

understood that conformity with the rules and values does not necessarily follow simply because they may be shared, but that an organized system of incentives and punishments should exist to encourage conformity (Parsons, 1990 [1934]). Robert Merton (1949) maintained that social structures could constrain behavior or present opportunities for social action.

This notion of stability has remained in modern considerations of institutions. As used in the social sciences, institutions are considered as social practices or conventions that achieve some sort of regularity through repetition, become legitimated by adherence to social norms, and contribute to the social structure (Eisenstadt, 1968a, 1968b). Based on his historical study of social institutions, Turner refers to institutions as "a complex of positions, roles, norms, and values lodged in particular types of social structures and organizing relatively stable patterns of human activity with respect to fundamental problems…" (J. H. Turner, 1997, p. 6). Institutions represent standardized patterns for social interaction (Jepperson, 1991).

What is commonly referred to as "old" institutionalism (DiMaggio & Powell, 1991a; Selznick, 1996) views social reality as constructed by the social interactions of humans. Selznick (1949; 1957) believed that organizations become institutions as their function attains a value higher than the work performed. The organization achieves a distinctive character and is identified with a particular competence (Selznick, 1996). Participants wish to see it continue to preserve those values. The old institutionalism was concerned with the formal structure of the organization and with local influences being determinate, indicating that organizations were both institutionalized and the

center of the process (W. R. Scott & Meyer, 1983). Old institutionalism uses social evolution to explain the formation and development of institutions, as individual activities become mores and blossom into institutions (W. R. Scott, 2001). Selznick emphasized how the history of the organization, environment, and particular adaptations shaped institutionalization over time. Old institutionalism focused on norms, values, and attitudes that participants internalized as they became socialized into the organization (DiMaggio & Powell, 1991a). Social actions become constrained by this context.

Institutional theory has moved away from this evolutionary concept over the past thirty years. Institutionalism as currently discussed in sociology diverges from the viewpoint of Selznick to embrace a broader theory that attempts to explain institutions, including how they arise and then persist in non-localized contexts (DiMaggio & Powell, 1991a). In many ways, it harkens back to the early writings on institutionalism that focused on social norms. Building on Durkehim's notion of methodological holism (Nee, 1998), "new" institutional thinking is an attempt to move beyond the approaches which viewed institutions as the collective of individual actions and failed to consider the social context (March & Olsen, 1989). New institutionalism, as discussed from the sociological perspective in the study of organizations, considers "larger environmental factors such as culture, social norms, and conventions" (Koelbe, 1995, p. 231). It is meant to counter the notion that organizations are shaped by technological or economic determinism by asserting they are influenced by the other social institutions in their environment (W. R. Scott, 2001).

New institutionalism is concerned with "the embeddedness of social structures and social actors in broad-scale contexts of meaning" (Jepperson, 2002, p. 229). This intellectual movement, starting with the work of Meyer & Rowan (1977), Dimaggio & Powell, (1983), and Zucker (1977), viewed society as comprised of institutions—each consisting of social structures constructed within broad frameworks—in which individual actors are embedded. At its core, the institutional tradition is concerned with the development of normative systems that govern human activity (W. R. Scott, 2001). Institutionalization begins with the habitualization of human activity, meaning that situations and activities can be experienced and repeated without having to be redefined each time. These repeated interactions come to produce shared meanings and stable belief systems among persons, forming the process called institutionalization. Social formations become transmitted to others and across generations as they become historical institutions (Berger & Luckman, 1967). Regular patterns of organization and interaction in life can be explained as taken-for-granted social relationships and actions located in social structures that are self-sustaining (Zucker, 1977).

Building on the Weberian explanation of legitimacy, in particular the legitimacy of rationalized formal structures (Lassman, 2000; Nee, 1998), institutionalized structures are based on an understanding of social reality that is widespread and thus deeply embedded in the social structure. Institutionalization involves individuals taking normative obligations into account in social processes, so much so that they "come to take on a rule-like status in social thought and action" (J. W. Meyer & Rowan, 1977, p. 341). Institutions have sets of rules that structure social interaction and those rules,

routines, and procedures are shared and understood by members of the community or society at large (March & Olsen, 1989). This differentiates institutionalism from individual actor theories, as norm-based models prescribe rules which may or may not be in the logical best interest of the individual actor, but which prescribe action nonetheless (DiMaggio & Powell, 1983; Knight, 1992). New institutionalism asserts there are scripts and rules that exist outside of any particular organization. This expands the explanations of how individual actions are similarly influenced. Whereas previous institutional theories proposed that people act only out of either personal interest (regulative), or out of duty or social expectations (normative), new institutionalism added the cultural/cognitive dimension. People are socialized into the organization or particular routines and beliefs because of learned patterns of behavior (DiMaggio & Powell, 1991a; W. R. Scott, 2001).

New Theorizing on "Choice-within-Constraints"

While the explanations for stability have been long-established in institutional theory, explanations regarding divergence have been more difficult to formulate. Moreover, this line of theorizing has led to reconsiderations of the entire line of scholarship and reflections on the theory as a whole (Greenwood & Hinings, 1996; P. M. Hirsch & Lounsbury, 1997; Selznick, 1996). Critiques of the new institutionalism call for a greater emphasis on the mechanisms producing divergence, since a focus on the macro-level (Zucker, 1991) can distract from differences occurring despite powerful isomorphic and environmental constraints (DiMaggio, 1988; Powell, 1991). The claims of the deterministic nature of institutions (J. W. Meyer & Rowan, 1977) are made

problematic by the understanding from earlier sociological writing that individuals have agency to make choices (P. M. Hirsch & Lounsbury, 1997; Nee, 1998; Selznick, 1996). DiMaggio & Powell (1991a) discuss at great length the differences between the old and new institutionalisms, with the focus primarily on their critiques of rational choice and behavioral theories that were used in the old institutionalism. Diverging from the notion that institutions could be formed through the aggregation of individual preferences or actions, or that institutions could be designed intentionally by individuals, new institutionalism in sociology viewed individual action as not only constrained but dependent on such macro factors as society and culture (Koelbe, 1995).

Viewpoints from other scholars and disciplines critique this position. Other disciplines like political science (March & Olsen, 1989) still view rational choice as essential, insisting that institutions affect choices but do not determine them. Theories within economics consider how institutions structure and regulate transactions, but assert that individual actors can still exert rationality within the constraints imposed by institutions (Brinton & Nee, 1998). Jepperson (1991), in discussing how institutions are reproduced, asserts that institutions do not just constrain—they also empower individual actors with a freedom to act within certain frameworks.

This line of thinking concurs with other new institutional thinkers, looking to expand the theory. New institutionalism recognizes that while there are exterior norms producing patterns that shape activity, institutions must also have an internal, cognitive order. While new institutionalism recognizes that institutions organize human activity, institutions also act as systems of ritual or symbolism that allow individuals to infuse

meaning into activity. The reproduction and perpetuation of an institutional order comes not just from the organizational structures and rules that govern activity; those structures and rules must have some meaning to individuals for people to carry them out in an effectual manner (Friedland & Alford, 1991). Institutions are not simply templates that organizations implement passively. Actors can view an institution as legitimate, but this becomes complicated because organizations face complex and differentiated environments, from which courses of action can be strategically selected. These multiple environments suggest many degrees of legitimacy, with varying levels of support or opposition (W. R. Scott, 1991).

Returning to some of the foundational ideas of institutions can be helpful. Building on the concept of roles from phenomonology, institutions are comprised of a diverse array of roles that are recognizable to outsiders (Berger & Luckman, 1967; Jepperson, 1991). However, institutions are not given and unchanging forms. People create or adapt institutions, not just respond to them. Role theory allows for people to role "make"—not just role play. Thus changes in social practices can create new forms and modify existing ones (Eisenstadt, 1968a, 1968b; W. R. Scott, 2001). The choice-within-constraints perspective (Nee, 1998) is reinforced by a theory also used in the study of social order—structuration (Giddens, 1984). Social practices are based on rules that are shared by persons connected through meaningful, shared communications. Rules structure action; society is predicated on people acting in accordance with expectations, while working within structures and following predictable routines gives people a greater sense of control of their lives.

In situations where rule-based actions are uncertain, individuals are free to choose from the knowledge of rules in their possession. This leads to the duality of structure: enacting rules enables structural reproduction but also provides opportunities for new forms. People exhibit agency when enacting structures; invocation of structures is also an opportunity for adjustment, since people can modify rules as appropriate. This is the recursive property of human activities (Cassell, 1993; Giddens, 1984), which contrasts with the view of some new institutionalists that institutions do not require active, collectivized action for reproduction because the mechanisms to encourage or discourage activities and interactions exist within the institutionalized patterns (Jepperson, 1991).

Rethinking social activities, structures, and institutionalism in this way is the project of theorists looking to reconcile the 'old' and the 'new' institutionalisms (Brint & Karabel, 1991; Nee, 1998; Selznick, 1996). Although some writers use the terms neo-institutionalism and new institutionalism interchangeably (DiMaggio & Powell, 1991a; W. R. Scott, 2001), others have made the specific point to utilize "neoinstitutionalism" as a term for this reconsideration of the theory as a whole (Greenwood & Hinings, 1996; P. M. Hirsch & Lounsbury, 1997). The reconciliation seeks to build bridges between the theories focusing on building structures through individual agency and those explaining action as determined by institutional structures.

Focusing on how new institutional forms arise and change occurs within institutions is a method for finding the link. New patterns of activity can be caused by environmental shifts or shocks to an institution (Hanson, 2001), ranging from new

regulations to dramatic changes in law, technology, or public demands. Also, institutions differ in their stability; institutionalization occurs in differing degrees, which can be conceived as how vulnerable the institution is to social intervention (Jepperson, 1991). Under certain conditions, either internal or external to the institution, sustained behaviors and practices can become susceptible to dissipation, rejection, or displacement (Oliver, 1992).

Applications to Universities & Academic Science

Institutionalism can be used to study how universities respond to their changing environment (Anderson & Seashore-Louis, 1991). As legitimacy is desired by all universities, for instance, functions inconsistent with socially-defined activities threatens their success (J. W. Meyer & Rowan, 1977) since a high degree of institutionalization prescribes that conventional practices should be maintained (Zucker, 1991). In higher education, social phenomena like academic tenure and the academic discipline can be considered institutionalized patterns where supporting and reproducing structures and practices exist to sustain them (Jepperson, 1991).

Some scholars have recently conceived of academic science as a highly institutionalized category of organizational activity that has meaning and value as a collection of related activities. Treating academic science as an institution allows for the study of the unwillingness of academic networks to accept emerging models for science as well as the potential for new policies, such as flexible reward systems, to legitimate these practices (Beesley, 2003). Funding mechanisms have also been shown to be a potential lever for changing normative systems about what constitutes good science, as

the introduction of alternate or parallel funding schemes from government can promote different models for science (Benner & Sandstrom, 2000).

Institutional theory is one means by which to study how universities interact with their environment, as the societal expectations for legitimate practices constrain behavior, thus raising the cost of change. As universities adopt new research practices, they may attempt to convince constituencies that new models of research are compatible with traditional values or that the idea of research should be expanded. Another adaptation is the creation of a buffer organization, like a research foundation, to conduct those activities seen to be inconsistent with conventional notions of research universities (Anderson & Seashore-Louis, 1991). Institutional approaches have also been used in a limited sense in studies of community colleges, using the theories to look for similarities across the faculty cultures of the colleges (Levin, 2006). Other evidence using the concept of sense-making suggests that faculty may use nostalgia for an idealized academia past as a means "to create continuity…in their own academic identities" (p. 571) as well as socialize newcomers into the morals of academia (Ylijoki, 2005).

Ideas of academic identity and socialization have been present in the formation of the scientific ethos. Merton, discussing how scientists required independence from political interference in 1938, describes an ethos with characteristics of strong institutionalization:

> The ethos of science refers to an emotionally toned complex of rules, prescriptions, mores, beliefs, values, and presuppositions which are held to be binding on the scientist…. Transgression is curbed by internalized prohibitions and by disapproving emotional reactions which are mobilized by supporters of

> the ethos. Once given an effective ethos of this type, resentment, scorn, and other attitudes of antipathy operate almost automatically to stabilize the existing structure (Merton, [1938] 1973, p. 258).

Parsons (1951) outlined how the institutionalization of scientific investigation comes from a cultural valuation of "rationality and understanding of the empirical world" (p. 340). Empirical knowledge is advanced through particular techniques used by persons in specialized roles, employing skills not possessed by those only interested in practical applications of knowledge. Consistent with Merton's discussion of Western culture and science, Parsons asserts that science is not automatically advanced, but rather, the process is guided by a cultural structure committed to developing knowledge beyond its immediate uses, a value he sees in Western culture. Also, given that science will challenge many traditional positions of society, its continued public legitimacy is dependent on factors beyond practical applicability of knowledge. The cultural tradition of science based on respect for evidence, rationality, objectivity, and investigation has become institutionalized as the model for science. As scientific findings and the contribution they make to education become valued, science becomes institutionalized as its values become inculcated in the value system of society (Mulkay, 1976; Parsons, 1951).

As this study seeks to determine whether there is evidence of different institutional narratives concerning academic science, it is helpful to study the theoretical faculty positions using institutional elements. An important component is the cultural-cognitive domain (Scott, 2001). Based on the contribution of new institutional theory in sociology that the cognitive dimension of individuals is important to understanding

replication of institutions (DiMaggio & Powell, 1991a), this element is concerned with the subjective beliefs and personal interpretations of individual actors. The cultural element is important because the culture can shape individual perceptions as to what is proper, important, and expected. Individuals can interpret cultural elements as meaningful as or symbolic of activities or beliefs that are taken for granted as appropriate. For this research, the cultural-cognitive element will be used to inquire about the personal beliefs of the individual faculty, apart from their perceptions of policies in their department or expectations from their discipline.

Synopsis of Conceptual Understandings

The preceding discussion of the transformations to academic science and the scientific ethos has focused, to a large extent, on values: traditional, modern, and values under stress or in conflict. Potential pathways to the resolution of these conflicts can be gleaned from the literatures examined here, using the theoretical perspectives and conceptual approach that informs this study. With the goal of presenting a summation of concepts that will lead to a better sense of the research design, several important understandings are highlighted below.

Findings Relevant to Control over Research Agendas

The literature review considered many theories and macro-level observations of the transformation of academic science. This treatment was necessary for the context of why faculty may perceive a loss of control over their research. Moreover, the macro perspective may also be important for understanding what "control" means to the

faculty in this study that are operating within the transformed environment. Still, as discussed in the section introducing the problem in Chapter One, study of these issues requires a focus at the micro-level. The concepts emerging as important for the four components of the analytical model (see p. 100) are summarized below.

One takeaway from the literature has to be that the social relations of knowledge production are increasingly important and cannot be separated from the practice of research. Thus, where faculty are positioned across the university, who is represented in their networks of interaction, and even their individual, particular values shape what topics they choose or the projects that appeal to them. For those faculty engaged in commercial science or entrepreneurship, entrepreneurialism takes many forms, most of which involve increased faculty engagement in activities that bring the work of the university closer to industry and other stakeholder publics. When faculty are in a department or research area that is closer to the market or commercial science activities, they tend to view that type of research as more legitimate. The variables in Box 1 of the model are intended to measure such engagement.

Box 2 of the model (see p. 100) includes variables that touch on policies and practices that address institutional responses to commercial science. This review has discussed how the entrepreneurial university is viewed as an organizational response to the transformed research environment, and is specifically viewed as introducing managerialism into the academy. For some, this is the adoption business practices, while others accept the innovative policies as necessary to extend the mission of the university. As a result, the policies and characteristics of individual universities become

important for knowing the extent to which faculty are encouraged toward or constrained from engaging in commercial science activity.

Personal and career variables emerge as important because faculty who are differently positioned across higher education, or that have had careers of different lengths or types, may feel differently about commercial science. The transformation occurring in academic science is an ongoing process which has not been uniform in its occurrence across academia or within particular sectors or types of institutions. We know from the literature to look for disciplinary differences, as well as those based on tenure, rank, and length in academia, or connection to industry (Box 3).

Finally, as part of the consideration of faculty values described below, study participants will be categorized as one of the four faculty types in a typology that is being tested for this research (Box 4). The five issues that were discussed in the literature review will form part of the process for differentiating among faculty for placement into these types (see p. 106).

Findings Relevant to Value Systems for Academic Science

The Mertonian Ideal

First, the Mertonian norms, and their attendant scientific practices, retain a place in the minds of scientists as a default ideal. This primacy of place resulted from Merton's role as the founder of the sociology of science, which provided a framework for the study of how the environment for science influenced its practice and development (Knorr-Cetina, 1991). Alternate theories for their perpetuation include the

development of a necessary ideology around science to guarantee both government support and non-interference, as it became necessary to defend science for lay audiences as a completely objective and rational process (Mulkay, 1976; Stokes, 1997).

Existence of Mertonian Science

Second, the available literature and evidence suggests that the model of Mertonian science does not reflect the reality of scientific practice, that all scientists conduct research in differing degrees of violation with at least one or even all of the norms, and that this situation has existed almost since the norms were articulated. Numerous empirical studies have tried to document the existence and universal applicability of Merton's normative structure of science, with little resulting evidence of consistent and universal application; several researchers intimated that Merton's system may be either a myth or simply a utopian ideal that operates as a goal rather than a governing system for practice (Hess, 1997; Kaplan, 1964; Mitroff, 1974; West, 1960). In any event, there is considerable evidence to show substantial deviation from the normative structure by practicing scientists (Braxton, 1986, 1990, 1993; Fishman, 1978).

Deviance to What ?

Third, acceptance of the evidence in the literature recording deviation from the Metonian values still leaves us with an important unanswered question: deviance to what? If Merton's norms do not guide practice, are there other models or conceptual approaches to science that are more legitimate, or at least more widely practiced? Are

academic scientists operating under a new value system, or potentially several systems, to guide their conduct (Etzkowitz, 1989)? Within higher education circles, there has been long-standing resistance in the literature to the possibility of innovative perspectives on scientific practice. Meanwhile, the modern sociology of science—more commonly called the sociology of scientific knowledge, or science studies—is attempting to answer these questions by moving beyond Merton's study of the context for science and focusing on its content (Hess, 1997; Knorr-Cetina, 1991).

Transformation through Adaptation

Fourth, this leads to the study of science as a social activity and the potential for the modification of the norms of science. The transformation of the research process is also altering the role of the individual faculty. However, this should not be seen as a shift in some external normative system, but rather, as the result of the changing views academic scientists hold regarding how science should be conducted. The structural changes in scientific practice allow those faculty involved to integrate the previously conflicting views regarding basic and entrepreneurial science through a social process of adaptation (Etzkowitz, 1989).

Some attempts have been made at this social approach in the higher education literature. A qualitative study of faculty involved in technology transfer examined the social relations among several groups involved in producing entrepreneurial science and asked whether the negotiation of conflicts was in fact re-norming academic science (Slaughter & Rhoades, 1990). Rather than treating social structures as exogenous systems that demand adaptation, the authors concluded the social structures are

constructed by participants within and outside the university. The ambivalence faculty felt produced negotiations over the control of science with involved individuals and groups. Thus, the alteration of the organization of science produces modifications to the normative structure of science through the negotiation of conflict in the transformed social relations of knowledge production (Slaughter & Rhoades, 1990). Interestingly, despite a value difference from Etzkowitz regarding the appropriateness of this transformation, Slaughter & Rhoades arrive at a similar description of causality: each acknowledges the rewriting of norms via the process of social construction.

Construction of New Institutional Forms

Fifth, the construction of new social structures and the notion that participants in knowledge production have the social agency—both individually and collectively—to transform the normative structure for academic science highlights the need for the perspective of institutionalism. This theoretical area informs this study by allowing that faculty could be creating and adopting new and innovative normative systems, despite the constraints of conventional perspectives of academic science. With institutions requiring human activity for replication, the freedom individuals have to adjust and recreate the rules of the institution or their own role in it becomes important as the social structures endure stress or become uncertain (Giddens, 1984; Jepperson, 1991; Nee, 1998).

The advent of entrepreneurial science presents university faculty with just such a state of uncertainty, similar to the ill-structured problems described by Mitroff (1974) that inspired NASA scientists to operate in accordance with an entire set of counter-

norms to Merton's system. Certainly the effects on faculty documented in this review constitute evidence of such stress. As conventional conceptions of academic science are challenged by new realties, faculty find their work environment altered, prompting the creation of new practices to adapt. Perhaps scientific process can adapt to novel circumstances through the social interaction of the knowledge producers, similar to the way proponents of entrepreneurial and Mode-2 science theorize (Etzkowitz, 1989; Etzkowitz & Leydesdorff, 2000b; Gibbons, 1995; Nowotny et al., 2001).

With these understandings as background, the subsequent presentation of the research design should be made clearer.

CHAPTER III. METHODS

Research Design

The foundations for this study are the concepts of control and values. Control is paramount as the motivation for the primary research question, and as an underlying concept for understanding normative systems and the regulation of behavior that are the subject of the second question. Values are important in each situation as they influence behavior. The conceptual understandings from the preceding pages serve as background: thus far, we know that the traditional norms for science have not been and are not always followed in practice, that science is a social process undertaken by persons in a dynamic environment of interaction, and that the transformation of academic science unsettles the conventional practices of research work. Being persons in a social situation, academic scientists have the potential to adapt by altering research practices and creating new frameworks for action. What is unknown is the extent to which this has actually happened.

This study seeks to explore the control faculty have to determine their own research agendas, and the control the academic profession exerts on the values that guide the manner in which that research is conducted, while determining which characteristics help explain the results. Its purpose is to produce some measurement of the extent to which faculty still feel they can determine the direction of their research

program, while also exploring whether potential alternate normative systems for science exist.

The two primary questions for this study are:

1. To what extent do university faculty feel the process for obtaining research sponsorship is compromising their ability to control their own research agenda?
2. Is there evidence to suggest the existence of alternate normative/ value systems among faculty regarding what constitutes academic science that differ from traditional ones?

In addition, the following sub-questions are introduced to further guide the analysis of the variables in the study.

3. What background characteristics are associated with the different faculty types representing differing notions of academic science?
4. What differences are present among faculty of different types regarding their perceived control of their own research agendas?
5. What factors predict the level of control over research agendas that faculty indicate they possess?

As discussed in the review of the literature, control over research direction and choice of topics are not frequently studied. More common are studies involving conflicts over the differing values of science and industry, deviations from existing normative systems, or changes to research practice. The most common approaches to studying faculty attitudes and beliefs concerning these and related issues have involved qualitative designs. In such studies, typical cases are illustrated with quotations and/or composite sketches of representative cases are provided. However, there is no way to determine the extent to which the given information represents all of the subjects in a

study (Fowler, 1993). Some quantitative approaches have been used, but with research control rarely a focus of research, findings are inconclusive.

The study is cross-sectional in nature, with the data collected at a single point-in-time from faculty at academic institutions from across the United States. The decision to sample from many institutions rather than just a few was made because of selection concerns. Having too many respondents from one institution would produce a sample with high within-group homogeneity (Groves et al., 2004). This lack of variance would make it difficult to obtain valid results because the research subjects would not be differentiated sufficiently in terms of background. Having subjects with similar experiences or frames of reference does not facilitate a study of significant distinctions that would explain variations among the participants.

A design with a special-purpose survey was chosen because there is no existing dataset inclusive of variables directly referencing either the norms of academic science or academic freedom issues related to faculty choice of research topics. An original survey instrument provides the opportunity to collect standardized measures on these issues from a targeted population and relate the data together for analysis so that broader generalizations can be made (Fowler, 1993).

Analytical Model

Figure 2 below is presents the research model for this study. At the bottom is the construct of *Control over the research agenda*—the primary dependent variable—which is measured using a summated-rating scale. Predictor variables are organized into four themed groups: 1) The first group is Commercial Science, and consists of

involvement in, knowledge of, activities within commercial science, as well as sources of research support. 2) The second group—Institution—includes policies and constraints regarding commercial science activity, and the Carnegie type, control, and research expenditures by source of funds. 3) The third group collects personal and career variables for the faculty respondents. These are gender, academic rank, time both as an academic and working in industry, tenure status, and discipline. 4) Faculty type, an endogenous variable to be determined in the study based on two concepts from the theory and typology described in the introduction and measured by items on the survey. A more detailed discussion of the variables, their origin, definition, and usage in the model is provided below.

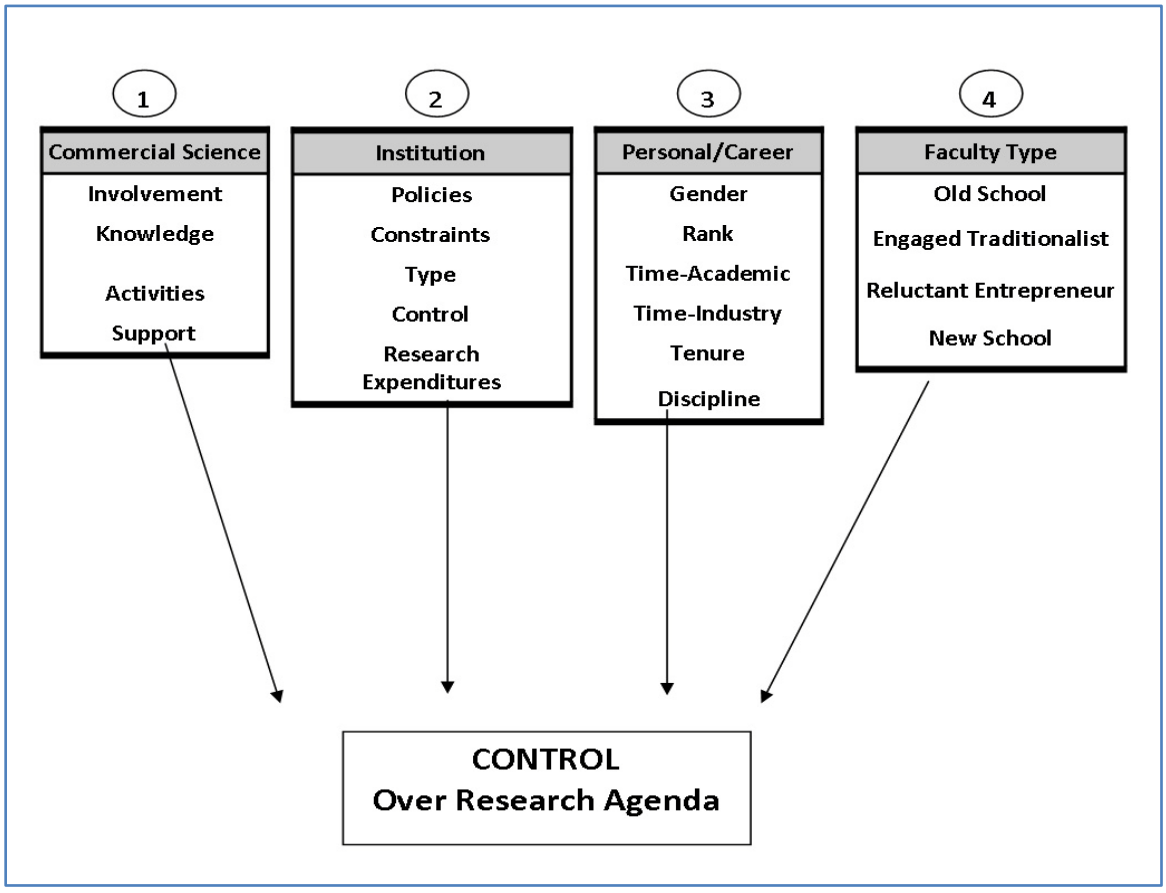

Figure 2: Analytical Model for Study

Description of Variables in the Study

This study utilizes an original survey instrument (see Appendix 1) consisting of one scale, two sections of attitudinal items, two sections of background/grouping items, and a few demographic items. The control scale was created to measure the primary dependent variable in the study: control over research topics. The attitudinal items are intended as a measure along the two dimensions of the typology theory and will be utilized to differentiate faculty in the analysis of the primary dependent variable.

A description of the question sets and information regarding the development of the individual items is provided below alongside a discussion of the research questions they are intended to address.

Dependent Variables: Control Over Research Agendas

Research Questions 1 & 5

1) ***To what extent do faculty members feel the process of obtaining research sponsorship is compromising their ability to control their own research agenda?***
5) ***What factors predict the level of control over research agendas that faculty indicate they possess?***

Survey question set 18 (12 items)

The primary dependent variable for the study (*control over research agenda*) will be derived from a multi-item scale measuring the latent variable construct 'control' (DeVellis, 2003; McIver & Carmines, 1981). Because the idea of control is both complex and abstract, the summated-rating scale is an appropriate technique to increase the reliability and precision of the measurement (Spector, 1992). This scale was developed

by the researcher based on examples and outcomes—both anecdotal and empirical—from the literature about university-industry relations, using a process summarized below. Conceptually, the items address different potential outcomes from the perspective of a faculty member attempting to secure funding from research sponsors for their topics of choice.

The items in the scale inquire about faculty perceptions of their control to determine their own choice of research topics, secure funding to support the work, and the influence they feel sponsors have over their choice of topics. Potential content for these items were developed in stages. Initially, the different outcomes were possibilities that covered the spectrum from success to failure, with an allowance for middle positions in which sponsors attempted to influence research topics. This was further developed to include a dimension for sponsors that consisted of them either being accommodating to the faculty member, or being a hindrance to their research goals. This enhancement led to consideration of various potential positions in which the faculty member could find themselves. Attempts to refine these concepts into a workable heuristic eventually led to the 2x2 matrix contained in Table 2, which summarizes the potential outcomes. These will be discussed as the Four C's and presented as outcome variables in the following section.

Table 2: Four Cs; Theoretical Positions Regarding Control over Research

		Perception of Sponsors	
		Cooperative	***Coercive***
Ability to Secure Sponsored Funding	***High***	Curiosity	Compromise
	Low	Collaboration	Concession

One dimension of the heuristic is faculty self-perception of their ability to obtain research funding. Although measured in this table with only two levels of high or low, in theory, faculty might consider criteria such as grant writing ability, status within the discipline, or networking connections with sponsors—among others—when rating themselves. The other dimension—perception of sponsors—is measured as either cooperative or coercive, returning to the idea of sponsors accommodating or hindering faculty needs. This would include perceptions such as sponsor agreement, any sponsor attempts to influence topics, acceding to sponsor demands, and adaptation of demands through negotiation.

In any of these four scenarios, the option to stop pursuit of the funding is an option, so although the consideration of failure or stop is not explicitly defined in one of the cells, it is embedded in the potential outcomes as an option at any point. All of these considerations were used in the development of the questions in this scale.

The resulting "control" scale contains 12 items inquiring about the perceptions of relations with sponsors and ability to determine research topics. This scale asks respondents to estimate how often they perceive given statements to be true. Items were measured using response categories for frequency that are proportional in nature, since these questions inquire about aspects of faculty work that will not vary with any degree of regularity. This allows respondents to think about frequency in terms of a proportion of their total time or events relevant to sponsored research (Fowler, 1995).

Scenarios regarding topic choice [The Four Cs] (Survey question set 12; 8 items)

Returning to Table 2, these four constructs—Curiosity, Collaboration, Compromise, and Concession (collectively labeled *The Four Cs*)—describe four possible scenarios that faculty could find themselves in during the process of obtaining sponsorship and determining their course of study. The four outcomes in the cells of Table 2 above inform the questions used in the control scale, but also present different conceptions of control in their own right.

Faculty were provided with a series of four scenarios regarding freedom of topic choice in the context of both government and industry funding. Questions for these scenarios were developed from the constructs outlined in the foregoing discussion of the development of the control scale. The outcomes have been given descriptive, conceptual names for illustrative purposes here, and are defined as follows:

- **Curiosity** (-driven research): Researcher is able to obtain funding to research topics based on interest
- **Collaboration**: Researcher and sponsor negotiate to work together towards shared goals
- **Compromise**: Researcher is compelled to yield some aspects of control while successfully fighting to maintain others
- **Concession**: Sponsor influence is such that funding can only occur by acceding to their demands

Endogenous Variables: Faculty Type

Research Question 2

Is there evidence to suggest the existence of different normative/ value systems regarding what constitutes academic science among faculty?

Attitudinal Variables for Classification (Typology)

Survey question sets 19-24 (26 items)

The attitudinal items used in the classification portion of the survey are based on the faculty typology discussed in the introduction and literature review (shown in Figure 3, p. 105) and the accompanying description of the types provided by the authors. The types were originally theorized as positions that faculty could assume in response to the changes in life sciences research. Each type is defined by the authors as comprised of a set of particular beliefs.

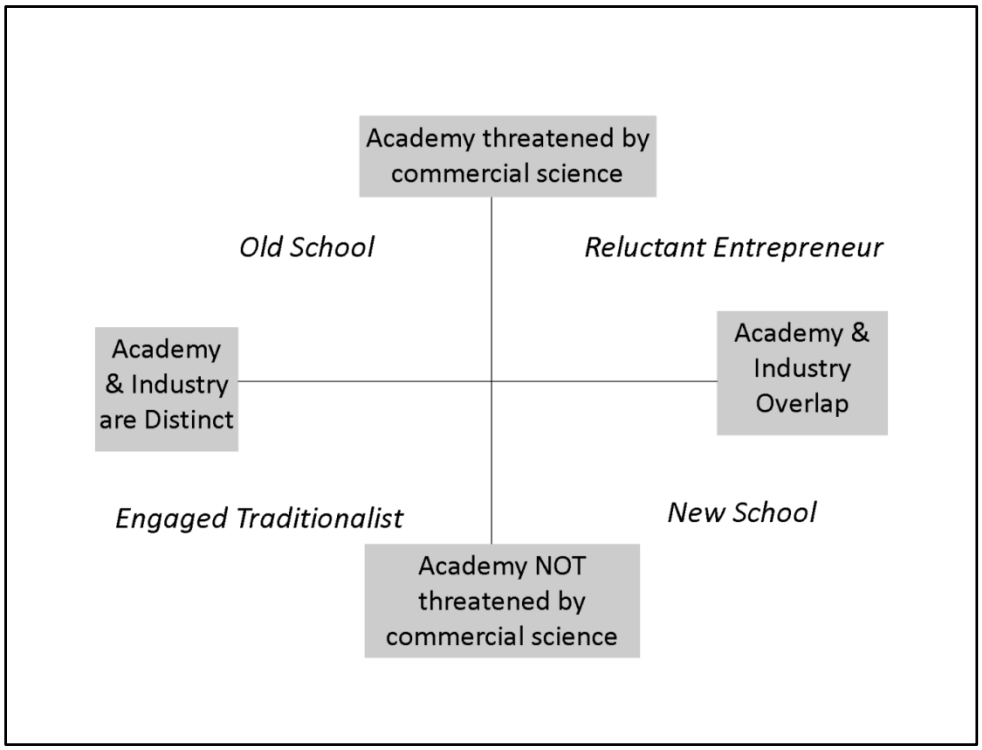

Figure 3: Typology of Faculty Positions

For this study, the typology theory was adapted to test whether the type constructs could serve as proxies for alternate institutional forms for academic science.

Since each type is the label for a set of values, this study operationalizes the types by seeing whether the expression of particular values will identify a respondent as a certain type. In the language of causality, the values that faculty profess should allow for the classification and identification of each faculty with one particular type. Type is viewed as the latent variable, and the answers given for the attitude and belief items are effect indicators. Thus, it is not presumed that being a certain type causes one to have a particular set of values; the values indicate the type.

Before any determination can be made regarding how the practice of academic science may potentially be changing, it must be shown that different value systems or institutional logics exist and are seen as legitimate by faculty. Testing these types within the context of specific issues seems a reasonable method for examining whether they could represent four alternate viewpoints on the complexities of academic science.

Survey questions were developed to test for the potential of four distinct viewpoints. Content for areas of comparison was created using the descriptions provided by the authors, "funneled through" a series of five issues common in the literature about commercialization and sponsored research that were discussed in the literature review. Drawing from the studies of faculty views on negotiating conflicts in academy-industry relations (Campbell, 1997; Campbell & Slaughter, 1999; Washburn, 2005), market relationships (Bok, 2003; Geiger, 2004; Slaughter et al., 2004), as well as from the theory of Mode 2 science (Gibbons, 1995; Gibbons et al., 1994; Nowotny, Scott, & Gibbons, 2003). Table 3 below summarizes theoretical positions for the four faculty types on the five common issues.

Table 3: Framework for Comparison of Faculty Types Using Commercialization Issues

TYPE	THEORETICAL POSITION	TYPE	THEORETICAL POSITION
OLD SCHOOL	1. Grants preserve autonomy 2. Problem-solving is not academic science; advancing knowledge is 3. Patents, IP concerns threaten autonomy 4. Involvement in startups, patents compromises research 5. Discovery; Recognition amongst peers	RELUCTANT ENTREPRENEUR	1. Private contracts tolerated as necessary for some research 2. Boundaries crossed to pursue interesting topics 3. Negotiate publishing/patents to preserve autonomy & university 4. Do what is necessary to avoid conflicts of interest & commitment 5. Dissemination of innovations through publishing, patents
ENGAGED TRADITIONALIST	1. Necessary to negotiate restrictions from both sources; no difference 2. Distinctions not critical; discovery possible through either 3. Industry has legitimate needs for restrictions; Patenting OK 4. Conflicts can be negotiated 5. Significant commercial involvement; startups	NEW SCHOOL	1. Possible to pursue funding that allows for research on projects of interest 2. Distinctions not relevant; Importance of topic, conducting quality research; Collaborations determine path of research 3. Restrictions, patenting, secrecy are legitimate parts of collaborations 4. Conflicts worked out amongst collaborators 5. Social accountability; Consulting, continued translational research

Note: 1= Funding, 2=Basic-Applied Research, 3=Publishing/Patenting, 4= Conflicts of Interest/Commitment, 5=Criteria for Success

The five issues are:

1) *Funding*, which concerns viewpoints on government/public agency grants vs. private contracts with industry;

2) *Basic-Applied*, which deals with views on the two types of research as traditionally considered;

3) *Publishing/Patenting*, an area inclusive of restrictions on publication, the filing of patents, and matters of intellectual property;

4) *Conflicts*, dealing with the negotiation of conflicts of interest or commitment; and

5) *Success*, regarding what criteria are generally accepted as indicative of quality science and success as a researcher.

Within each cell, the statements numbered 1 to 5 correspond with the five issues, and represent beliefs that a person with the accompanying type would ideally hold to be true, based on the type descriptions provided by the authors (Owen-Smith & Powell, 2001). These statements are the basis for the attitudinal items in this section of the survey.

The survey items in this section contain five sections—based on the content areas—with one question within each section corresponding to one of the four faculty types. Twenty items were created using the cells in the table above—one for each intersection of the four faculty types and the five content areas (issues). There is also a general section consisting of six questions addressing differences between any faculty types along one of the two dimensions in the typology created by Owen-Smith & Powell (2001). Each question is designed to distinguish between two types that converge in a particular way. In the theory, the attitudes of any two faculty types will converge in some aspects since two types will always be on the same side of one of the primary dimensions, while the types on the diagonals also share some general attitudes about academic science. In total there are 26 items.

Self-placement on type dimensions (Questions 10 & 11)

The typology is constructed from two primary dimensions. These questions ask respondents to place themselves on the dimensions as if they were a spectrum. The Threat/ No threat Overlap/Distinct labels were provided as definitions of the endpoints

of the spectra, but no other points along the scales were defined—not even neutral, with the intent that people would define for themselves what the points meant. Seven-point Likert scales were chosen to provide greater variability in responses. This rating method was used so that it could be compared with the type ratings derived from the more complex series of questions, based on the original theories and the issues addressed with these items. Faculty respondents will be classified using this method, and then given another classification by the more complex criteria, and the resulting differences will be explored.

Independent and Control Variables

Research Question 3

What background characteristics are associated with the different faculty types representing differing notions of academic science?

Commercial Science (Survey question sets 14 – 17)

The survey section entitled "Personal involvement in commercial science" covers different areas of experience with commercial science. The first set asks about the highest level of involvement each faculty has experienced with an invention, since previous research indicates that those faculty involved with commercial science are more likely to view it favorably (Campbell & Slaughter, 1999; Matkin, 1997). A second section on activities asks faculty to indicate whether they have been involved with any of the processes listed—this is so a simple count can be made. The third question is a self-rating on the level of knowledge they feel they personally have about commercial science procedures. Although this uses vague quantifiers (DeVellis, 2003), the scale

offers enough distinction for respondents to place themselves. The fourth set requires a breakdown of the percentage of research support that comes from different sources. It includes government (Federal, state, and public agencies), Industry (business, corporations, contracts), Foundations (private organizations, associations), university support, and other.

External influences on commercial science (Survey questions sets 8 – 9)

Several variables will also address the characteristics of the respondents' environment for research and commercial science. Self-reported items include statements about policies in place at the home institution, as well as constraints on practice that come from external pressures. Question set 8 contains 7 items asking faculty to evaluate statements about different aspects of the policies and environment for research that exists at their university. These can be seen as the climate/culture for science, as well as constraints. Question set nine is concerned with pressure that faculty may perceive from their institution regarding commercial science activities and sponsored research, in area like commercial topics, applied outcomes, limiting publication, and generating revenues.

Data about the institutions will be obtained from the Carnegie Foundation for the Advancement of Teaching, the National Science Foundation, and the IPEDS database. These institutional variables are its Carnegie classification, its control as public/private, and measures for research expenditures. The NSF provides totals for research expenditures as well as a breakdown by source of funds.

Faculty career variables (Survey questions sets 2 -7)

A beginning section on "Professional background" collects information about each faculty member's rank, years in academia, years in industry, tenure status, primary academic discipline, and administrative duties. One of the important hypothesized differences among faculty could be between academic disciplines. This allows for the determination of similarities or differences regarding research norms and agendas across academic fields. Disciplinary differences do exist with respect to scientific norms; those faculty in disciplines more predisposed to theory-building and paradigm development have been shown to adhere more closely to traditional scientific norms (Fishman, 1978).

Faculty are certainly aware of causal mechanisms such as regional and environmental pressures for development, but they also understand what drivers exist within the universities and disciplines themselves. For instance, working in a discipline with a "mirror industry" that presents potential corporate partners and customers, as well as the pursuit by that industry of commercial interests can influence university/department decisions regarding commercial involvement. Those faculty perceive the need for collaboration more acutely, and universities with clearer statements of support functions and roles enable faculty to move in that direction (Laukkanen, 2003). Differences in hard vs. soft disciplines have also been demonstrated (Anderson & Seashore-Louis, 1991). In an attempt to observe such distinctions, faculty will be sampled from five different academic fields—broadly considered—including disciplines such as:

- Biological sciences (e.g., Biology, Botany, Zoology)
- Physical sciences (e.g., Chemistry, Physics, Geology)
- Engineering (e.g., Chemical, Civil, Electrical, Mechanical)
- Medical sciences (e.g., Allied Health, Public Health, Medicine)
- Social sciences (e.g., Psychology, Economics, Political Science, Sociology)

Research Question 4:

What differences are present among faculty of different types regarding their perceived control of their own research agendas?

This aspect of the study examines the differences in perceived control by faculty of differing types. Based on the theory, it should be expected that Old School faculty would perceive their situation to be changing at an uncomfortable pace, while New School faculty believe the changes are necessary and appropriate. The hybrid positions should be mixed, with the differences turning on how much can be handled at an individual level without compromising the academy, and how much is absolutely necessary to get by.

Description of Population, Sample, and Data Collection

Data Source

The sampling frame (Groves et al., 2004) for the survey was a pool of faculty from across the US, utilizing a database maintained by a professional marketing company that solicits participation from college and university faculty. A firm called Firstmark, Inc. maintains databases and provides direct mailing services and telemarketing lists to businesses. The databases the company provides enable access to

professionals in government, health care, financial services, and other industries. Being one of the few such companies to target education specifically, their database includes educators in both K-12 and higher education, as well as specific populations by job or school type. Names are compiled from institutional directories and are guaranteed to be current within the previous 18-month period.

Firstmark states that the database available for college and university faculty contains more than 1,000,000 faculty and department chairs from 20 broad academic areas. Fee-based access to the lists are provided electronically in Excel or CD format, with specificity of the lists determined in advance in collaboration with Firstmark using several selection criteria.

Sample

Since most previous research has worked with relatively small datasets, the objective for this study was sample of 5,000 faculty from research and doctoral universities in the United States to allow for analysis of the large number of items in the instrument scales. The pool of available faculty in the data source was winnowed by several criteria available in the database. First, to ensure selection from research and doctoral universities, while allowing for a broader sampling than just large state or private universities, the pool of institutions from which faculty were drawn narrowed to the 282 institutions classified in the 2005 Carnegie Basic Classification System as Doctorate-granting universities. These institutions fall into three categories: Research universities with “very high” or “high” research activity, and Doctoral/Research

universities. Utilizing specified ZIP codes from IPEDS, 1000 faculty within each of the five disciplinary areas of interest were selected from the 282 institutions.

Given the direct access to the faculty via the database, single-stage sampling was used for this study. The unit of analysis in the study is individual faculty members, although they are included in the database by their institutional affiliation and other characteristics. A systematic stratified sampling technique was employed (Babbie, 1983), since certain characteristics of the population are known in advance (Fowler, 1993). As the study is designed to examine faculty across disciplines, this was the primary level of stratification. Equal representation in the population from the five disciplinary areas was obtained, and the database provider generated a sample using a random start.

The final sample of eligible participants for the survey was 4,540 from 252 institutions. The purchased dataset had a number of coverage errors, resulting in a large percentage of people (> 40%) who were ultimately deemed ineligible for the study. Most often, the errors were because a person either was not tenure-track faculty, not faculty at all, or because the directory information was simply outdated and the person listed was no longer there. Because of these coverage errors, replacements were found for each person deemed ineligible, using a staff of temporary research assistants trained to help with the coverage errors and replacements that were required to produce an accurate dataset for the survey sample. Even with these efforts, several hundred people were eliminated during the administration of the survey for reasons such as being emeritus faculty, no longer being an active researcher, or being wrongly classified

as a researcher. There were not sufficient resources to allow the staff to complete a second round of replacements.

Survey Design

The survey was designed to be conducted online, using a commercially-available web-based data collection and analysis program known as SurveyMonkey.com, following a period of parallel testing. The advent of internet survey programs presents many new opportunities to survey researchers. In terms of survey design, web surveys offer greater flexibility with survey design, functionality, and content, as well as additional features that can increase the motivation of respondents to complete the questionnaire. Still these new options come with a responsibility to the designer to use them for purposes of maximizing data quality and minimizing error (Couper, Traugott, & Lamias, 2001).

For instance, computer-assisted surveys can reduce skip errors because they require participants to answer all questions, although there can be higher non-response at the individual level if people are intimidated by the technology. In addition, computer-assisted surveys can increase the legitimacy of the questionnaire to the respondents, and has been shown to reduce the cognitive burden on individuals as they respond to the questions (Tourangeau, Rips, & Rasinski, 2000). Web-based designs also have the potential to achieve efficiencies in terms of time, logistics, and cost in the use of self-administered questionnaires. Moreover, although there is some concern among survey researchers that internet coverage and proficiency is insufficient to allow for use

with many populations, surveys of certain populations—such as university professors—will likely experience only minor coverage problems (Dillman, 2000; Groves et al., 2004).

A web-based design was chosen to facilitate data entry since the sample for the study was large. Although email is a common practice with commercial internet survey programs, email addresses for participants are not available from the database provider. In fact, no database service contacted included email addresses for faculty in their records. Because of this, email addresses were obtained during the process of correcting coverage errors and locating replacements discussed earlier. Accuracy among those sampled was verified through the directories of individual institutions. Anyone without research activity was excluded and replaced, as were faculty who were emeritus.

Instrument Testing

Consistent with established survey techniques (Fowler, 1993, 1995; Groves et al., 2004), the instrument was subjected to some preliminary testing. Due to the large scope of the intended study, a large scale field test was cost-prohibitive. Moreover, as this study is a first attempt to examine the particular constructs of interest, it was deemed more appropriate to perform tests on the constructs themselves, as well as the items intended to measure them.

The type of pretesting performed for this study has been variously called review by knowledgeable analysts (Dillman, 2000) or expert review (Caspar, 2004), as well as intensive individual interviews (Fowler, 1995) or cognitive interviews (Scheuren, 2004). Such reviewers can include persons similar to those in the intended subject pool,

methodologists and data analysts, as well as people who have expertise in the constructs of the survey and can identify with potential respondents. The purpose of this form of testing is to determine how respondents understand the questions and feel about the response tasks; it is not an effort to simulate full-scale data collection (Fowler, 1995). The goal at this stage is to "finalize the substantive content of the questionnaire so that construction can be undertaken" (Dillman, 2000, p. 141).

A population of 50 individuals was compiled from lists of research faculty, technology transfer officials, and methodologists known to this researcher from previous project work and research positions. These individuals either knew the researcher directly, had contact with the researcher through interaction during prior research, or had some familiarity with the researcher in his capacity as a colleague on previous research projects in which they participated. Each individual was sent an email invitation to participate in the instrument testing—either directly from the survey program or directly from this researcher—along with a link to the web survey. Participants were asked to read through the survey questions, instructions, and response scales, and address the following questions, if they found something of concern:

- Do the questions make sense? Is anything unclear?
- Do the questions seem appropriate to the target population (university research faculty)?
- Should any questions be added? Deleted? Changed in some way?
- Does the wording of the questions seem relevant to the experience of sponsored research?
- What is your opinion on the concept of controlling one's research agenda?
- How long did it take to work through it? Did it seem too long?

From this population, nine individuals indicated they could assist in the instrument testing. Seven persons provided feedback through email dialogue with the researcher, and two individuals agreed to be interviewed about the survey. Among those who provided feedback, five were technology transfer officials from three different public universities in Michigan, three were research faculty, and one was a survey methodologist from the Institute for Social Research.

These individuals affirmed the general structure and focus of the draft sent to them, although several important revisions resulted from their feedback. All confirmed that the concept of control was a legitimate topic for faculty to address in this format, and that the questions about sponsored research were presented in a way that was reasonable. Some requested clarification between federal and industry sponsorship on one set of questions, while others offered additions for the questions about institutional policies and constraints. From their contributions, the researcher was able to make revisions that clarified the meaning of several questions, expanded the answer choices for others, and altered instructions or questions that seemed inappropriate, misleading, or confusing.

This type of review from knowledgeable experts offering some important advantages has, while also possessing a few important limitations. These reviews are a cost-effective means for identifying a wide variety of potential problems, such as the layout or logic of the survey, or the way concepts have been operationalized. Still, there is no realistic feedback from actual respondents, and it remains unknown how the questions will be understood in the field (Caspar, 2004; Fowler, 1995). It is also possible

that some aspects could have been missed by the reviewers because they are dividing their attention between the content of the survey and the task of responding to review questions (Dillman, 2000).

Data Collection

In October 2008, the online survey was administered to 4,540 research faculty from a pool of 252 institutions classified in the 2005 Carnegie Basic Classification System as Doctorate-granting universities. Following three rounds of follow-up contacts, usable responses were received from 1,210 faculty, producing a response rate of 26.7%, which is an average rate for internet surveys, averaging below mail rates, but which are more cost-effective (Kaplowitz, Hadlock, & Levine, 2004).

Preliminary Analytical Procedures

This section discusses how the research questions will be addressed and includes groundwork analyses, data manipulations, and the testing of variables to be included in the analysis. First will be the factor analysis performed on the 12-item control scale and the creation of the primary outcome variable for the study. Next is the initial attempt to use the typology as a classification scheme and examination of the resulting distribution, which is the precursor to the comparison with the method used in the analysis. Then other procedures will be discussed with respect to the remaining research questions.

Data Reduction

Research Question 1:

To what extent do faculty members feel the process of obtaining sponsored research funds is compromising their ability to control their own research agenda?

Because this question is dependent upon the creation and determination of other values from the survey data analysis, it is necessarily being addressed last in the data analysis. However, it is conceptually important to discuss it first here. The question of faculty control to determine research topics is addressed by the 12-item scale. The first step was data reduction using exploratory factor analysis to create the construct to be tested, and then determine the reliability of the scale for the primary dependent variable.

Factor analysis (Grimm & Yarnold, 1995; Kim & Mueller 1978a, 1978b) was used to determine if the scale was indeed unidimensional (McIver & Carmines, 1981) and the determination of internal consistency of the scale yields information about the homogeneity of the individual items. The items will have strong association with the latent variable if they have a strong relationship with one another, as they are all presumed to be measuring the latent variable—in this case, control (DeVellis, 2003). Variables determined not to be part of a reliable scale were considered for use as single dependent variables.

A factor analysis with PCA extraction and varimax rotation was performed on the initial 12-item scale, resulting in a one factor solution, following reliability testing (Table 4 below). The factor which emerged is comprised of 7 items and can best be defined as

"Self-directed research" and is based on questions answered on five point Likert scales ranging from 1=Always to 5 = Never. Answers in the negative indicate a higher level of control or freedom from interference of sponsors. The scale has a moderately high estimate of reliability (**α = 0.86).**

Table 4: Factor Loadings and Lists of Dependent Variables

Item #		Factor Loading	Communalities
	Factor 1: Self-directed Research	**α = 0.86**	
6	Researching topics of interest to my research sponsors keeps me from studying topics important to me	0.84	0.70
9	I have to compromise my research interests in order to secure funding for any research	0.83	0.69
5	I alter the focus of my research to accommodate the project goals of my research sponsors	0.77	0.59
2	Sponsors of research actively attempt to influence my choice of research topics	0.71	0.51
7	My research sponsors have specific problems they want me to research for them	0.70	0.50
3	Inability to find funding keeps me from pursuing the problems of greatest interest to me	0.67	0.45
12	I am restricted from conducting basic research with the funding I am able to raise	0.65	0.42
	Dependent Variables		
		Mean	SD
1	I am able to find research funding for the questions I wish to pursue (1 = Never, 5 = Always)	3.41	0.81
11	I am concerned that my commercial activity will compromise my ability to conduct objective science (1=Always, 5=Never)	4.46	0.96
Factor	Self-Directed Research (Composite: Original code; 1=Always, 5=Never)	3.57	0.83

Although other components were extracted in the solution, none produced reliable factors scales, as reliability scores only increased when the scales were reduced to two items. Thus, two individual items were used as dependent variables for other

estimates of control. The first is question 1 listed in Table 4, on which faculty would rate their success in finding money to research what they wish, with '5=Always' being the high score. The second item to be used singly is number 11, which asks about concerns that commercial activity will compromise the objectivity of one's science (5=Never).

Additional Outcome Variables for 'Control'

Dependent variables for control were also derived from the topic-choice scenarios that faculty rated for frequency of occurrence. The four Cs—Curiosity, Collaboration, Compromise, Concession—were rated in the context of both government and industry funding scenarios, thus producing eight measures of control. Because of the natural pairings of these variables, the four categories were compared to determine any mean differences between the two funding contexts. These variables were also used in group comparisons for variables that are theorized to be important, such as faculty type and academic discipline, as well as for regression models. Comparisons were also made between measures of affirmative scenarios of control—Curiosity and Collaboration, and the negative scenarios representing the overcoming of sponsor interference with research—Compromise and Concession.

Academic Science Typology

Research Question 2:

> ***Using theorized faculty types as proxy, is there evidence to suggest the existence of alternate normative/ value systems among faculty regarding what constitutes academic science that differ from traditional ones?***

The next step in the analysis was the determination of the faculty types. These types are proxies for the existence of different institutional forms, and to the extent that substantial numbers of respondents fall into types other than the traditional Old School type, there may be some evidence of legitimately different conceptions of academic science. Provided there is an appropriate distribution among the types, a regression model with the categorical variable could be estimated.

Self-Placement on Typology Dimensions

The first method for classification was to discover the distribution that resulted from faculty placing themselves on the two primary dimensions of the typology: Threat-No threat and Overlap-Distinct (see Figure 3, p. 105, and Appendix 1, Q 10-11). Each respondent placed themselves on a spectrum representing each dimension, measured in seven point scales. Using that data, as a crude method for classification, each respondent's score was allowed to vary randomly because the limited number of possible values (seven discrete points) would otherwise place many respondents at exactly the same point in space. Using the added random variance, they were placed into high and low halves of each of the two dimensions using the midpoints of the scales as cut points. The combination of these scores for each respondent acted as

coordinates on a graph, and each respondent was placed into one of the 4 quadrants of the 2x2 matrix. The resulting distribution is shown in Table 5.

Table 5: Type Classification Based on Self-Placement on Primary Dimensions

	Frequency	Valid Percent
Old School (OS)	332	28.8
Engaged Traditionalist (ET)	407	35.3
Reluctant Entrepreneur (RE)	139	12.1
New School (NS)	274	23.8
Total	1,152	100.0

In a Chi-square test, the distribution of these types differed significantly from a placement simply using each dimension's mean as the cut point with no random variation (χ^2 (3 (N=1152) = 129.07, $p < .001$). Old School (28.8%) and Engaged Traditionalist (35.3%) are the most common types, perhaps suggesting that when asked to place themselves, the ends of the dimensions that indicate a moderate perceived threat from commercial science and greater perceived distinction between academic and commercial science are attractive to faculty.

Graphically, the clustering around Old School and Engaged Traditionalist, and the relatively small numbers for Reluctant Entrepreneur based on these self-ratings can be seen in Figure 4 below. The axes and dimensions in this graph correspond to those in the depiction of the typology in Figure 3 (p. 105). Even with the random variations, there is still clustering around the values of the scales, but the trend of clustering away from the Reluctant Entrepreneur position vs. the other three types can be discerned.

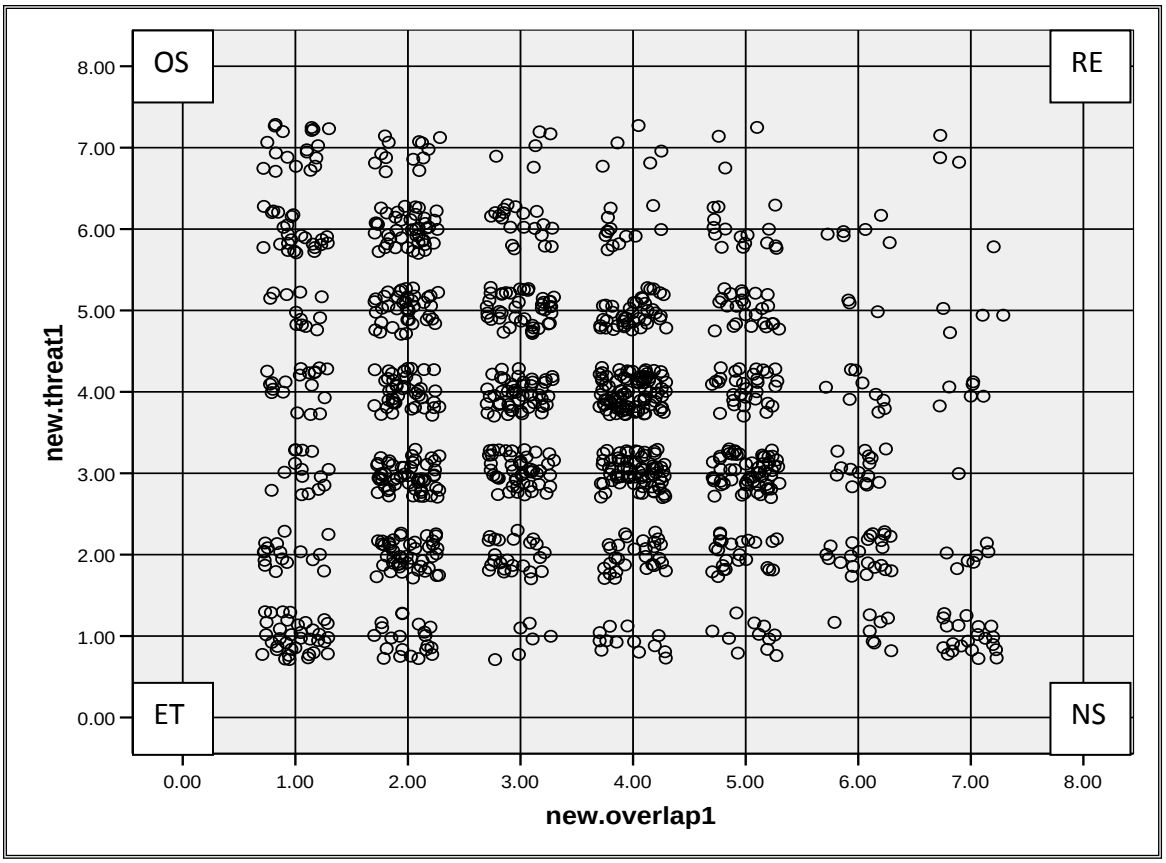

Figure 4: Scatterplot of Faculty Self-Ratings on Two Dimensions of Typology

Another classification was created using the 20 items in the survey about values for academic and commercial science. Indices were created using means of the items associated with each type, and faculty respondents were assigned a preference based on their comparative scores, with some uniform random variance introduced to break ties. Bivariate correlations and graphical analysis were used to make determinations of the potential for distinct types. The distribution from this self-placement and the distribution from the indices will be compared in the results chapter .

Group Differences and Predictor Variables

Research Question 3:

What background characteristics are associated with the different faculty types representing differing notions of academic science?

A complete answer to this question is dependent upon the typology emerging as an effective classification scheme, which would mean the type constructs themselves truly represent distinct constructs. This portion of the analysis involves descriptive presentations of the survey results to summarize the general nature of the responses and to create a profile of the faculty participants. The analysis here also outlines which variables have the potential to contribute to the statistical models for the measurement of the control variables. The analysis begins with frequency distributions, and also considers groups comparison of means using ANOVAs to examine variables that could prove significant predictors in the regression models. Ultimately, this question will be answered in those models.

Research Question 4:

What differences are present among faculty of different types regarding their perceived control of their own research agendas?

Here, analysis of variance is employed to test group differences for the outcome variables that define control and look for relationships among the independent and dependent variables. This consists of analysis of the factor used as the primary dependent variable—Self-Directed Research.

Research Question 5:

What factors predict the level of control over research agendas that faculty indicate they possess?

Finally, the model for the analysis of the primary dependent variable will be utilized. To obtain an understanding of the factors that contribute to the variability in the level of personal control indicated by the control scale, OLS regression will be used. The primary dependent variable will be regressed on the complete set of independent variables. The regressions analyses allow for an estimation of the fit of the proposed model on the dependent variable, these analyses allow us to determine the effect of personal, career, commercial involvement, and institutional variables on the types and the level of personal control over research topics.

Summary of Survey Variables

Table 6 below summarizes the variables in the study and their source. For the dependent variables measuring control, there are two different sets of variables. One set is the multi-item scale derived from the factor analysis. It contains seven items and measures the construct of "Self-Directed Research." The second set will consist of eight models for the Four Cs—four for government funding and four for industry sponsorship. The other two dependent variables used in the study were from the original control scale.

The predictor variables listed will be used in all of the OLS regression models being estimated for the study.

Table 6: Variables in the Study

VARIABLES	Description/Coding	Item(s)
DEPENDENT VARIABLES		
Self-directed research	Factor Scale (7 items) (1 =Low; 5= High)	**18**
Four Cs	8 Scenarios [4 Gov't, 4 Industry] (1= Low, 5= High)	**12**
Securing funding	Scale item 1	**18**
Objectivity concerns	Scale item 11	**18**
ENDOGENOUS VARIABLES		
Faculty Type Indicators		
Funding	Likert (1=Disagree Completely, 5=Agree Completely)	**20**
Basic/Applied	Likert (1=Disagree Completely, 5=Agree Completely)	**21**
Publish/Patent	Likert (1=Disagree Completely, 5=Agree Completely)	**22**
Conflict	Likert (1=Disagree Completely, 5=Agree Completely)	**23**
Success	Likert (1=Disagree Completely, 5=Agree Completely)	**24**
Overlap *(Dimension#1)*	(1=Distinct, 7=Overlap)	**10**
Threat *(Dimension #2)*	(1=Threat, 7=No Threat)	**11**
INDEPENDENT VARIABLES		
Policies	Likert (1=Disagree Completely, 5=Agree Completely)	**8**
Constraints	Likert (1=None at all, 5=An enormous amount)	**9**
Involvement	Choice (Single answer; 1-8)	**14**
Knowledge	Choice (Single answer; 1-5)	**15**
Activities	Choice (Multiple answers; 1-10)	**16**
Support	Open-entry (4 prompts; Amounts sum to 100%)	**17**
CONTROL VARIABLES		
Personal Demographics		
Gender	Dichotomous; M,F	**25**
Career		
Rank	Full, Associate, Assistant, Clinical, Lecturer	**2**
Academic	Years as an Academic	**3**
Industry	Years in Industry	**4**
Tenure	Tenured, On Track, Not on Track, No Tenure System	**5**
Discipline	Biological, Physical, Med, Engineering, Soc Sci	**6**
Institution		
Type	Carnegie classifications: RU/VH, RU/H, DRU	**IPEDS**
Control	NSF; For-profit, Private, Private-religious, Public	
Research Expenditures	NSF; 2007 data, by source of funds	**NSF**

Description of Respondents

Faculty Profile/ Background variables

The 1,210 faculty respondents in this study are drawn from 252 doctoral/ research universities and colleges from across the US. Tables 7 and 8 below collect the descriptive information about the respondents based on information from the survey. Table 7 below presents two variables that are unique to this survey. Table 8 provides summaries of common variables and comparisons with national data. The comparison data comes from the National Science Foundation (NSF) and the Integrated Postsecondary Education Data System (IPEDS).

Table 7: Descriptive Statistics for Unique Survey Variables

Years in Academia			Years in Industry		
	Frequency	Valid Percent		Frequency	Valid Percent
0 -7 years	292	24.2	Never worked in Industry	698	57.9
8 - 15 years	338	28.0	Worked less than 1 year	101	8.4
16- 24 years	303	25.1	1- 5 years	222	18.4
25 + years	272	22.6	6 years or more	184	15.3
TOTAL	1,205	100.0	TOTAL	1,205	100.0

These faculty have been academics for many years. The majority has no direct experience working in industry, although one-third have worked outside academia in this capacity. They are active researchers, as emeritus faculty or anyone found to have primarily a clinical affiliation with their institution was excluded from the sample and this respondent pool.

Moving to Table 8, the faculty are drawn from five broad disciplinary areas, with Engineering being the least represented (some engineering faculty indicated they did not consider themselves academic scientists and declined to participate) and the

Medical/Health sciences providing the largest pool. The majority are women, as female faculty were intentionally oversampled.

Table 8: Comparative Descriptives of Faculty Population

Primary Discipline	Survey Population		National Population	
	Frequency	Valid Percent	Frequency	Valid Percent
Engineering (all types)	164	13.6	22,810	12.5
Medical/ Health Sciences	290	24.0	11,200	6.2
Physical Sciences	223	18.4	28,430	15.6
Biological Sciences	255	21.1	53,430	29.4
Social Sciences	277	22.9	66,050	36.3
TOTAL	1,209	100.0	181,920	100.0
Present Academic Rank				
	Frequency	Valid Percent	Frequency	Valid Percent
Professor	470	39.0	61,454	37.7
Associate Prof	404	33.6	48,789	29.9
Assistant/ Res Scientist	330	27.4	52,815	32.4
TOTAL	1,204	100.0	163,058	100.0
Tenure Status				
	Frequency	Valid Percent	Frequency	Valid Percent
Tenured	807	66.9	94,540	58.0
On tenure track	291	24.1	38,887	23.8
Not tenured	108	9.0	29,631	18.2
TOTAL	1,206	100.0	163,058	100.0
Gender				
	Frequency	Valid Percent	Frequency	Valid Percent
Male	519	42.9	138,415	64.0
Female	691	57.1	77,789	36.0
TOTAL	1,210	100.0	216,204	100
Institution Type				
	Frequency	Valid Percent	Frequency	Valid Percent
Very high research activity	686	56.7	228,785	62.8
High research activity	352	29.1	94,217	25.9
Doctoral/Research Universities	172	14.2	41,379	11.4
Total	1210	100.0	364,381	100.0
Control Type				
	Frequency	Valid Percent	Frequency	Valid Percent
Public	973	80.5	239,782	65.8
Private	236	19.5	124,599	34.2
Total	1209	100.0	364,381	100.0

Source: IPEDS, NSF

For the purposes of creating a picture of the general faculty population from which this sample was taken, to the general faculty population in the types of universities of interest in the study, Table 8 displays frequency distributions for academic rank, tenure status, gender, and discipline. Using IPEDS data from 2006 on faculty demographics, data on academic rank and tenure status was available on full-time research faculty for 178 of the institutions. The NSF data on discipline is from the Division of Science Resources Statistics, 2003 Survey of Doctorate Recipients.

The sample has a slightly higher percentage of Professors and Associate Professors than the population, and 5% fewer Assistants. The sample is skewed toward more tenure since it has almost nine percentage points more professors, only half the percentage value of non-tenured faculty (18.2% v. 9.0%), with roughly equivalent proportions of faculty on the tenure track. Regarding gender, the oversampling of women was mentioned above, and the resulting sample represents almost an inverse of the population, with e 64-36 split in the population and a 57.1% to 42.9% split in the sample, a difference of roughly 7 percentage points on both groups.

Table 8 also summarizes the distribution of the faculty respondents among the three institutional types, and by public-private control of their respective institutions. Comparative data for these two items can also be found in Table 8 above. More than half (56.7%) are from institutions classified as having “very high research activity,” which is below the population level of nearly 63%. The proportions from institutions with “high research activity” (29.1%) and “doctoral/ research universities” (14.1%) are both slightly above their respective population percentages of 25.9% and 11.4%. Regarding

control type, over 80% of the sample faculty are from public universities, while the remaining private grouping includes both religious and non-religious schools. Thus, the respondent pool is oversampled in faculty from public universities and is underrepresented with regards to faculty from private institutions.

Table 9 below breaks the sample down into groups based on the percentage of their funding they estimate comes from government and industry sources. For the government funding, 31% of the sample report no such support; the remaining faculty were divided into quintiles to obtain meaningful stratification (higher within-group similarity) across the 100-point spectrum, while also creating roughly equal group sizes for analysis. Overall, the data reveals that these faculty support their funding from diverse sources, as only 339 (28%) report having 90% or more of their funding coming from government sources.

Table 9: Self-Reporting of Research Support, For Government and Industry Funding

Percentage groupings, government funding			Percentage groupings, industry funding		
	Frequency	Percent		Frequency	Percent
No Government funding	375	31.0	No Industry funding	939	77.6
1 to 49%	154	12.7	1 to 24%	154	12.7
50 to 75%	209	17.3	25 to 100%	117	9.7
76 to 89%	133	11.0			
90 to 99%	169	14.0			
100 %	170	14.0			
Total	1210	100.0	Total	1210	100.0

The grouping analysis was a little more challenging for the industry-funding data; more than three-fourths (77.6%) of the faculty report no industry funding for their research. With the same goal for grouping as above, the remainder of the faculty was placed into two groups. For these respondents, the smallest percentage of faculty (9.7%) reports the larger percentages of industry support (25% to 100%).

CHAPTER IV. DATA ANALYSIS AND RESULTS

This chapter has four main components. First is a descriptive summary of the independent variables; second is the analysis of the faculty typology—including classification—which will address Research Questions 2 and 3. The third and fourth sections each analyze data that answers Research Questions 1 and 5. The third section is an analysis of the control scenarios defined as the Four Cs, while the fourth section is the analysis of the primary dependent variable—Control, measured by the variable "Self-Directed Research." This section includes an examination of group differences (which also addresses Research Question 4) and the OLS regression models.

Descriptive Summary of Independent Variables

This presentation of descriptive statistics corresponds to the survey questions, which can be referenced in Appendix 1.

Institutional Influences on Research

Institutional Policies for Commercial Environment

Table 10 below summarizes the means and standard deviations for the seven items that asked about the institutional climate and environment for research. This set contained items that asked about policies that were both supportive and those that incentivized research and commercial outcomes. Faculty generally feel that their

institution offers a supportive environment for entrepreneurship, patenting and licensing, and for resolving conflicts, as these were the highest rated items. There was not much agreement that institutions restrict the publication of research results when it comes to commercial science. Finally, there was general disagreement that institutions require faculty to offset their salaries with external research funds, while there was only slight agreement with the notion that universities provide internal funds to faculty for research support.

Table 10: Descriptive Statistics for Institutional Environment for Research

	N	Mean	SD
Has an "entrepreneurial environment" that encourages the commercialization of research	1072	3.51	1.12
Requires me to offset part of my salary with external research funds	1141	2.67	1.63
Provides financial assistance to support aspects of my research program	1144	3.14	1.24
Has policies that restrict publications derived from sponsored research	956	1.60	0.91
Offers procedural support for faculty involved in patenting/ licensing of innovations	836	4.03	0.90
Has policies to help faculty prevent/resolve conflicts of interest/ commitment	894	3.88	0.92
Rewards commercial activity in promotion/tenure decisions	808	2.94	1.16
Valid N (listwise)	546		

Note: 1=Disagree completely, 5=Agree completely

Institutional Pressures/Constraints

Table 11 below provides the descriptive statistics for the five variables asking about institutional constraints, or pressures that faculty feel to achieve particular outcomes associated with commercial science. The 5-point scales for these variables have been re-coded, collapsing the two highest levels into a single category. Based on these data, it does not appear that these faculty perceive great internal pressure to

make their research commercial. None of the means here approach the level of "moderate (3)", indicating that respondents generally express a sentiment closer to "only a little (2)" pressure to have the focus or produce the results considered here.

Table 11: Descriptive Statistics for Pressure for Commercial Outcomes

	N	Mean	SD
Select topics with commercial potential	1115	1.68	0.98
Focus on applied outcomes	1136	2.45	1.16
Commercialize research results	1102	1.57	0.87
Limit publication of research results	1133	1.17	0.51
Generate revenues from research	1123	1.93	1.13
Valid N (listwise)	1070		

Note: 1=None at all, 4=Significant/Overwhelming

Personal Experience with Commercial Science

Involvement

The first question set dealing with personal involvement in and experience with commercial science (CS) was adapted from an existing scale (Matkin, 1990), and asked faculty to indicate the highest level of involvement they had ever achieved with an invention or technology developed from commercial science activity. The frequency distribution is shown in Table 12 below.

Table 12: Frequency Distribution for Highest Level of Commercial Involvement

	Frequency	Percent
No CS activity	444	36.69
No invention/ No action	399	32.98
Pub findings, gave to sponsor	85	7.02
Submitted invention disclosure	53	4.38
Applied for patent	53	4.38
Obtained patent	49	4.05
Licensed invention	19	1.57
Received royalty income	62	5.12
Start-up from tech	46	3.80
Total	1210	100.00

Almost 70% of these faculty (36.69% + 32.98% = 69.67%) fell into the first two categories listed, indicating that they either had no commercial science activity, had not had such an invention, or took no action with any invention. The remaining levels indicate small percentages of faculty having experienced involvement with the other components of working with academic inventions. Still, beginning with the fourth category—"Submitted invention disclosure"— 282 faculty (representing 23.3%) have at least started down the path of submitting an invention disclosure, with 46 of those indicating a start-up based on their research. By this measure, the bulk of the faculty in this sample has not been commercially active via inventions, but a moderate-sized group has traveled far along this path.

Activities

Table 13: Highest Number of Commercial Science Activities

	Frequency	Percent
No Involvement	554	45.79
1	212	17.52
2	176	14.55
3	108	8.93
4 or more	160	13.22
Total	1210	100.00

Table 13 above summarizes the data for the item that provided faculty with 10 examples of commercial science activities such as consulting, research parks, or industry collaborations (see Appendix 1), and asked them to indicate whether they had ever been involved in them. Positive indications were totaled for each respondent and the data are presented as here as the counts for each possible total. The counts were below 50 for all categories of five activities and above, and were less than 10 for the four

highest levels, so for analytical purposes, these categories were combined into one level of "4 or more." While the largest group of faculty has "No involvement," totaling the number with at least one commercial science activity reveals that more than half (54.2%) have some current involvement as part of their normal duties. Whereas most faculty are not involved in business development from inventions, it would appear many faculty have some exposure to this realm of activity.

Personal Knowledge

Faculty were provided with a five-point scale with which to assess their own level of knowledge regarding commercial science processes and activities, especially in the context of the previous questions about inventions and commercial science activities. This scale ranged from "no knowledge" to "sophisticated knowledge." Table 14 below shows the frequency distribution for the results, with the two highest categories combined. Over half of the faculty indicate possessing "vague" knowledge (50.72%) of the commercial science world, with another 22.55% acknowledging "No knowledge". Combining the top two groups, over one-quarter (26.72%) have at least "reasonable" knowledge. Again, it would seem that the majority of these faculty are not directly involved in commercial science, but that those who are have learned from their experience.

Table 14: Frequencies for Self-Assessment of Commercial Science Knowledge

	Frequency	Valid Percent
No knowledge	249	22.55
Vague knowledge	560	50.72
Reasonable knowledge	214	19.38
Substantial/ Sophisticated	81	7.34
Total	1104	100.00

Funding Sources

Faculty were asked to estimate the percentages of their research support that comes from various sources: 1) government, inclusive of federal and state levels and agencies, 2) industry, business, and corporations, 3) private organizations, such as foundations and professional associations, 4) university support, and 5) other.

Table 15: Descriptives and ANOVA, Effects of Discipline on Research Funding Sources

Funding Source	Engineering (all types)		Medical/ Health Sciences		Physical Sciences		Biological Sciences		Social Sciences		ANOVA F (4, 1204)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Government/ public agencies[1]	61.68	35.80	38.68	39.67	61.98	38.16	65.17	36.16	30.05	37.79	45.74***
Industry/ corporations[2]	13.96	20.71	4.37	13.46	7.08	17.65	4.91	12.30	2.81	13.53	15.62***
Foundations/ private organizations[3]	3.54	8.75	13.29	24.16	3.99	11.36	7.11	16.47	8.33	19.43	11.92***
University support[4]	13.07	25.83	24.63	33.63	15.55	27.15	13.90	24.67	35.33	39.90	22.72***
Other	2.26	13.63	3.16	16.08	2.88	15.42	1.45	8.09	4.35	18.91	1.33

Notes: Means are percentages; η^2 = effect size; *** = $p < .001$
Effect sizes: [1] $\eta^2 = 0.13$, [2] $\eta^2 = 0.05$, [3] $\eta^2 = 0.04$, [4] $\eta^2 = 0.07$

Table 15 above provides the mean percentage levels of support indicated, by source and academic discipline, from all sources. Not surprisingly, most support comes from the government, with an average higher than 60% for the biological and physical sciences and engineering faculty. Social science faculty rank last in government funding, but depend on the highest average levels of internal university support. Industry funding is highest for engineers and lowest for social science faculty. The medical science faculty indicate a broad support, with less than 40% from government, almost a quarter from university funds, and 13% from foundations. Across all disciplines,

university support is higher than industry funding, except for engineering where they are almost equal.

Overall, there is wide variability in the data provided by respondents, owing to both the estimated nature of the data and the natural differences in actual levels of funding received by such a diverse group. Also, there was a significant effect of academic discipline on all funding sources except 'Other', indicating statistically significant differences by discipline within these types of funding sources.

Summary

Faculty indicate the environment at their universities is generally supportive of commercial science activity, and that there is not overwhelming pressure to limit publications of results or skew their research towards commercial outcomes. The involvement in and knowledge of commercial science seems to be concentrated in about one-quarter of the overall respondent pool, although more than half are involved in at least one commercial science activity. Finally, their research is primarily government funded, with industry support ranking third or fourth in terms of percentage of support for all disciplines, except engineering, where it ranks second.

Typology Variables (Res Q's 2 &3)

This section of the analysis will address the second research question which focuses on the existence of alternate normative systems for academic science, and the third question regarding differences in background characteristics between types. First, two methods for placing faculty in the typology will be compared, then group

differences will be analyzed, and finally, the potency of the typology as a classification scheme will be tested, while also examining the integrity of the type constructs themselves.

Self-Placement on Primary Typology Dimensions

Rather than choose a type description that most appealed to them, faculty were asked to place themselves on two spectra—presented as seven-point scales—representing the two primary dimensions of the typology. The goal was to determine whether plotting the scores on these dimensions like coordinates on a graph would produce a distribution of faculty among the types that would differ from a distribution made from a more intricate classification method.

First is the Overlap dimension (M=3.37, SD=1.59) which asks whether academia and industry are distinct realms or whether they overlap. The other is the Threat dimension (M=3.65, SD=1.60), and asks whether or not they believe the academy is threatened by commercial science. With higher numbers meaning Overlap and Threat, the means below the midpoint suggest these faculty see the academy and industry as more distinct, but that the academy is moderately threatened by commercial science (see Figure 3, p. 105). The distribution from this self-rating, first presented in Chapter 3, will be compared with one produced from the index measures, as described below.

Index Preferences (Composite Measures)

Beyond the self-reporting on the two main dimensions of the typology, a more complex measurement of the proposed types was created using the constructs

discussed in Table 3 (p. 107). Combining the description of the types with issues common in the literature on commercialization, a series of items was created that presented respondents with statements on the issues from the perspective of each type (Table 16, p. 142). Since each type has five associated issue questions, composite variables were created averaging the means. Table 16 presents the issue statements, descriptives, and their corresponding theorized faculty type.

Looking at the issues in isolation, the scores for the funding statements indicate faculty believe that academic and commercial science have some compatibility, with the lowest score (2.94) coming for the Reluctant Entrepreneur position and the highest (3.86) for the Engaged Traditionalist position. The division between basic and applied science seems less important than topic importance, as the Old School position here scores lowest (1.76) and the Engaged Traditionalist position is the highest. For publishing /patenting, there is support for restrictions being seen as legitimate, although not to protect sponsors. Still, the Old School position favoring publication over IP restrictions has the highest score. Conflicts seem to worry faculty regarding their potential effect on academic science, and they seem to rate solutions by university policies and individual faculty negotiation about equally. However, the highest scoring item concerns the reward systems being separate.

Table 16: Descriptives for Issue Statements, with Corresponding Type Association

	Mean	SD	N
FUNDING			
Funding academic research with government grants is the best way to preserve faculty autonomy *(Old School)*	3.63	1.00	1,035
Both government grants and private contracts come with legitimate restrictions that faculty must negotiate *(Engaged Traditionalist)*	3.86	0.74	1,018
Private industry contracts should only be obtained as necessary to advance academic science *(Reluctant Entrepreneur)*	2.94	1.04	1,005
Private industry contracts can advance academic science with as much legitimacy as government grants *(New School)*	3.37	1.00	1,016
BASIC/APPLIED			
Applied research should be the domain of government and industry scientists, not academics *(Old School)*	1.76	0.87	1,052
Faculty are able to conduct commercial research while maintaining traditional academic values *(Engaged Traditionalist)*	3.62	0.84	1,004
Engaging into commercial activity is necessary to protect academic research from further encroachment by industry *(Reluctant Entrepreneur)*	2.41	0.85	910
Topic importance is a more vital research consideration than its classification as pure or applied science *(New School)*	3.41	1.14	1,031
PUBLISHING/PATENTING			
Academics should favor publication of results over any intellectual property protections *(Old School)*	3.70	1.01	1,020
Publication restrictions are legitimately needed to protect research sponsors *(Engaged Traditionalist)*	2.53	1.01	959
Patents and restrictions on private intellectual property are needed to protect academic science from industry *(Reluctant Entrepreneur)*	3.37	0.93	917
Patenting, and intellectual property restrictions are legitimate parts of research collaborations *(New School)*	3.47	0.90	935
CONFLICTS OF INTEREST/COMMITMENT			
Involvement with commercial activities fundamentally alters the academic environment for openness *(Old School)*	3.29	1.00	985
Academic recognition and commercial success are independent reward systems *(Engaged Traditionalist)*	3.59	0.95	986
University policies prevent conflicts of interest better than training individual faculty on industry engagement *(Reluctant Entrepreneur)*	3.16	0.99	876
Potential conflicts can best be addressed by individual faculty through negotiations with research sponsors *(New School)*	3.23	0.99	946
CRITERIA FOR GOOD SCIENCE			
Success should be evaluated primarily on traditional criteria like publications and contributions to the field *(Old School)*	3.98	0.88	1,050
Success can be measured by either academic achievement or significant commercial involvement, such as patenting *(Engaged Traditionalist)*	3.40	0.97	1,037
Success can be viewed as disseminating results and innovations through publications and patents *(Reluctant Entrepreneur)*	3.95	0.69	1,042
Success comes from applying academic research to solve important practical problems *(New School)*	3.73	0.99	1,043
Valid N (listwise)			675

Note: 1=Disagree completely, 5=Agree completely

For success in science, there is general agreement with the conventional viewpoints about evaluations of good science, but also agreement regarding the use of values consistent with commercial science and the non-conventional systems of thought. Regarding these last two issue areas, it is possible that respondents had trouble drawing the distinctions between the type positions that the theory would indicate, or that the respondents would view their answers as context-dependent, rather than seeing the positions as widely applicable.

In creating the indices, the questions that corresponded to each type were averaged in each case to create a composite score for that type. Because a person could still have types with the same mean score, uniform random variance was again introduced for the purpose of breaking ties. Each faculty respondent was given a composite score for each type, and values were compared to classify each person based on their highest score. Interestingly, using these indices produces a different frequency distribution then does the use of only self-placement on the two primary dimensions. The comparison is presented below in Table 17.

Table 17: Comparison of Classification Methods for Faculty Type

	Self-placement, 2 dimensions		Index Preference	
	Frequency	Valid Percent	Frequency	Valid Percent
Old School	332	28.8	292	27.1
Engaged Traditionalist	407	35.3	256	23.8
Reluctant Entrepreneur	139	12.1	123	11.4
New School	274	23.8	406	37.7
Total	1,152	100.0	1077	100.0

In comparison to the initial classification, in this distribution, the largest group of people has their highest scores on the New School items (37.7%), which increased

almost 14%, while Old School still has the second largest group (27.1%), dropping nearly two points. Engaged Traditionalist drops from first to third (23.8%), losing 11.5 points, while Reluctant Entrepreneur retains roughly the same proportion as before, while losing 0.7 points. Expressed as preferences, 35.2 % of the faculty had the highest agreement with the statements represented by the hybrid positions, and including the New School preference, 72.9% of these respondents expressed the highest agreement with a position other than that of the traditional, conventional views of academic science—the Old School position.

Returning to the dimensions outlined in the typology theory (Figure 3, p. 105), this distribution indicates a preference for the positions with less perceived threat from commercial science and greater perceived overlap between the realms of academic and commercial science, especially in the growing preference for New School. This observation indicates that when faculty are presented with a more complex picture of the issues related to academic and commercial science—such as the five issues incorporated into the study—and the different perspectives for science represented by the faculty typology, they indicate more tolerance for the ambiguity presented by the changing environment for sponsored research.

Shifting the analysis to the integrity of the type constructs themselves, Table 18 below presents a crosstabulation of the outcomes from these two placement procedures to allow for a comparison of the distribution among the types. A high level of consistency among the two classification schemes would yield the highest percentages along the main diagonal, similar to a correlation matrix. However,

consistency was only observed for the two primary types. For these data, the Old School (retaining 46.1%) and New School (retaining 56.5 %) have the highest carryover from one classification to the other, while the two hybrid positions have their largest percentage of faculty classified as New School.

Table 18: Comparison of Self-Placement and Index Preference Distributions

Self-Placement		Index Preference: Old School	Engaged Traditionalist	Reluctant Entrepreneur	New School	Total
Old School	N	143	54	45	68	310
	% Self-Placement	46.1%	17.4%	14.5%	21.9%	100.0%
	% Index Preference	49.3%	21.2%	37.2%	16.8%	29.0%
Engaged Traditionalist	N	90	106	44	137	377
	% Self-Placement	23.9%	28.1%	11.7%	36.3%	100.0%
	% Index Preference	31.0%	41.6%	36.4%	33.9%	35.2%
Reluctant Entrepreneur	N	34	25	15	56	130
	% Self-Placement	26.2%	19.2%	11.5%	43.1%	100.0%
	% Index Preference	11.7%	9.8%	12.4%	13.9%	12.1%
New School	N	23	70	17	143	253
	% Self-Placement	9.1%	27.7%	6.7%	56.5%	100.0%
	% Index Preference	7.9%	27.5%	14.0%	35.4%	23.6%
TOTAL	N	290	255	121	404	1070
	% Self-Placement	27.1%	23.8%	11.3%	37.8%	100.0%
	% Index Preference	100.0%	100.0%	100.0%	100.0%	100.0%

The largest overall distribution shift to the New School position came from the Reluctant Entrepreneur position; as these two positions share a belief that the academy and industry overlap, perhaps the issue questions revealed that many in this group do not consider view commercial science as the threat they might think at first. Still, over half of those classified as Old School using the index preferences were other types using the self-placement method of measurement. Perhaps the issue statements make their preference for conventional notions of research clearer as well.

Group Differences

Using the index classification, the first element for examination of differences among the faculty types will be how they break down across the academic disciplines sampled. Chi-square analysis provides strong evidence of an association between discipline and type (χ^2 (12, N=1077) = 73.46, p < .001). The results are in Table 19 below.

Table 19: Distribution of Types by Academic Discipline

		Academic Discipline					
Type		Engineering (all types)	Medical/ Health Sciences	Physical Sciences	Biological Sciences	Social Sciences	Total
Old School	Count	31	35	68	92	66	292
	% within Type	10.6%	12.0%	23.3%	31.5%	22.6%	100.0%
	% within Discipline	20.3%	14.1%	33.7%	38.8%	28.0%	27.1%
Engaged Traditionalist	Count	44	60	52	47	53	256
	% within Type	17.2%	23.4%	20.3%	18.4%	20.7%	100.0%
	% within Discipline	28.8%	24.1%	25.7%	19.8%	22.5%	23.8%
Reluctant Entrepreneur	Count	6	37	17	21	42	123
	% within Type	4.9%	30.1%	13.8%	17.1%	34.1%	100.0%
	% within Discipline	3.9%	14.9%	8.4%	8.9%	17.8%	11.4%
New School	Count	72	117	65	77	75	406
	% within Type	17.7%	28.8%	16.0%	19.0%	18.5%	100.0%
	% within Discipline	47.1%	47.0%	32.2%	32.5%	31.8%	37.7%
TOTAL	Count	153	249	202	237	236	1077
	% within Type	14.2%	23.1%	18.8%	22.0%	21.9%	100.0%
	% within Discipline	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Some findings are as expected: engineering (47.1%) and the medical sciences (47%) have their highest representation among the New School type, while engineers are lowest on Reluctant Entrepreneurs (3.9%). Old School has its lowest representation in the disciplines that could be expected, engineering (10.6%) and the medical sciences (12%), while having higher proportions among the physical (23.3%) and biological (31.5%) sciences, which typically prize basic research more highly, and the social sciences (22.6%) which generally do not have opportunities to participate in commercial science research.

Some surprising findings include the highest proportion of social science faculty appearing as New School (31.8%), and the relatively consistent proportions of Engaged Traditionalist types across the five disciplines. Both the medical (30.1%) and social (34.1%) sciences have a high proportion of faculty falling into the Reluctant Entrepreneur type, which is more understandable for the social science group than it is for the medical science faculty.

This breakdown does point out the fact that all four faculty types are represented across these five disciplines, indicating again that it may be difficult with this typology to reliably place faculty in mutually exclusive categories. However, it does add support to the idea that academic science is being conducted with differing value structures across the university, and not just in one or two specialized fields that are close to industry.

Besides discipline, the only other career variable to show an association with faculty type is years worked in industry (χ^2 (9, N=1074) = 71.65, $p < .001$). Academic rank, tenure, and years as an academic showed no significant associations with type. Table 20 below shows the crosstab for faculty type by "years worked in industry." There appears to be an association between New School and years worked in industry, as those having worked both "1- 5years" and "6 years or more" have their highest representation within New School. However, both Old School and New School have roughly equal proportions of faculty among those who have "worked less than 1 year" or "never worked" in industry. Among the hybrid positions, Engaged Traditionalist is

preferred by wide margins in every category, except in the "Never worked" group, where the gap closes.

Table 20: Faculty types, by Years Worked in Industry

		Old School	Engaged Traditionalist	Reluctant Entrepreneur	New School	TOTAL
Never worked in Industry	Count	195	128	94	203	620
	% within Industry Work	31.5%	20.6%	15.2%	32.7%	100.0%
	% within Type	67.2%	50.0%	77.0%	50.0%	57.7%
Worked less than 1 year	Count	31	31	6	29	97
	% within Industry Work	32.0%	32.0%	6.2%	29.9%	100.0%
	% within Type	10.7%	12.1%	4.9%	7.1%	9.0%
1- 5 years	Count	49	52	13	84	198
	% within Industry Work	24.7%	26.3%	6.6%	42.4%	100.0%
	% within Type	16.9%	20.3%	10.7%	20.7%	18.4%
6 years or more	Count	15	45	9	90	159
	% within Industry Work	9.4%	28.3%	5.7%	56.6%	100.0%
	% within Type	5.2%	17.6%	7.4%	22.2%	14.8%
TOTAL	Count	290	256	122	406	1074
	% within Industry Work	27.0%	23.8%	11.4%	37.8%	100.0%
	% within Type	100.0%	100.0%	100.0%	100.0%	100.0%

Among the variables measuring personal experience with commercial science, Chi-square analysis does show strong evidence of an association between 'knowledge of commercialization processes' and type (χ^2 (9, (N=1062) = 20.34, p = .016). Table 21 below presents the contingency table for these variables. The data present modest evidence that an increase in commercial science knowledge is associated with being New School, with the "reasonable" and "substantial" categories being more highly represented among New School than those indicating 'No' knowledge, while even those indicating 'vague' knowledge more often fall into the New School type.

The percentage of each category falling into Engaged Traditionalist declines slightly as the knowledge level increases, until a jump in the final grouping. Among those indicating 'substantial/sophisticated knowledge,' Engaged Traditionalist is second only to New School in its proportion of faculty. Finally, Reluctant Entrepreneur also

seems to show a negative association with commercial science knowledge, as its proportion decreases as the level of knowledge rises; it seems the more they learn, the less they like it. Also, while the overall percentages are higher, Old School presents this same inverse relationship pattern.

Table 21: Faculty Type, by Knowledge of Commercial Science Processes

		Old School	Engaged Traditionalist	Reluctant Entrepreneur	New School	TOTAL
No knowledge	Count	75	57	34	64	230
	% within CS Knowledge	32.6%	24.8%	14.8%	27.8%	100.0%
	% within Type	26.0%	22.4%	28.6%	16.0%	21.7%
Vague knowledge	Count	146	130	58	213	547
	% within CS Knowledge	26.7%	23.8%	10.6%	38.9%	100.0%
	% within Type	50.5%	51.2%	48.7%	53.3%	51.5%
Reasonable knowledge	Count	50	43	23	92	208
	% within CS Knowledge	24.0%	20.7%	11.1%	44.2%	100.0%
	% within Type	17.3%	16.9%	19.3%	23.0%	19.6%
Substantial/ Sophisticated	Count	18	24	4	31	77
	% within CS Knowledge	23.4%	31.2%	5.2%	40.3%	100.0%
	% within Type	6.2%	9.4%	3.4%	7.8%	7.3%
TOTAL	Count	289	254	119	400	1062
	% within CS Knowledge	27.2%	23.9%	11.2%	37.7%	100.0%
	% within Type	100.0%	100.0%	100.0%	100.0%	100.0%

Among the other variables measuring personal experience with commercial science, there is also a general trend for greater involvement equating to New School placement, and less involvement leading to an Old School one. Chi-square analyses for 'involvement in commercial science inventions' and type (χ^2 (24, (N=107) = 39.91, p = .022) and 'number of commercial science activities' and type (χ^2 (12, (N=1077) = 62.98, p < .001) each reveal significant associations with faculty type. The extent to which these associations persist in the presence of other variables will be determined in the models predicting the dependent variable of control over research agendas.

Regarding the variables inquiring about university policies for commercial science, one-way ANOVAs revealed five variables presenting significant group

differences among the faculty types. Descriptive statistics and group differences are presented in Table 22 below. Two variables dealing with the environment for commercial science—'offers financial support for my research' ($F(3, 1060) = 4.099$, $p = .007$), and 'has policies to resolve conflicts of interest' ($F(3, 829) = 4.157$, $p = .006$) — each had significant differences between Old School and Engaged Traditionalist. The effect sizes were small (0.011 and 0.015, respectively), but these data indicate that Engaged Traditionalist faculty feel greater support for their research than do Old School types, but that both perceive some support in these areas.

Table 22: Mean Scores & One Way ANOVAs on University Policies, by Faculty Type

	Old School		Engaged Traditionalist		Reluctant Entrepreneur		New School	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
My institution: [1]								
Offers financial support for my research	2.95_{a}	1.26	3.30_{a}	1.25	3.17	1.16	3.19	1.23
Has policies to resolve conflicts	3.74_{a}	0.95	4.06_{a}	0.88	3.92	0.90	1.67	0.97
In my research, I feel pressure to: [2]								
Select topics with commercial potential	1.67_{a}	0.97	1.69_{b}	0.97	$1.39_{a,b}$	0.75	1.77	1.02
Focus on applied outcomes	2.24_{a}	1.13	2.40_{b}	1.14	2.33_{c}	1.14	$1.60_{a,b,c}$	0.91
Commercialize my research results	1.60_{a}	0.91	1.55_{b}	0.85	$1.29_{a,b,c}$	0.53	1.64_{c}	0.92

[1]Note: 1=Disagree completely, 5=Agree completely
[2]Note: 1=None at all, 2=Only a little, 3= A moderate amount, 4=Significant/Overwhelming
Note: Means sharing subscripts within a row are significantly different.

With respect to the variables asking about pressure for commercial science outcomes, three— 'select topics with commercial potential' ($F(3, 1040) = 4.665$, $p = .003$), 'focus on applied outcomes' ($F(3, 1057) = 7.727$, $p < .001$), and 'commercialize research results' ($F(3, 1027) = 4.992$, $p = .002$) —presented several significant differences between faculty types. Both Old School and Engaged Traditionalist express

more pressure than do Reluctant Entrepreneur types to select commercial topics. Engaged Traditionalists indicate the most pressure to focus on applied outcomes, while New School types express less pressure than all the others. Reluctant Entrepreneurs also indicate the lowest pressure to commercialize their results, while New School express the highest. In all three cases, the effect sizes are small (0.013, 0.022, and 0.014, respectively).

These data, combined with what did not produce significant differences, indicate that the faculty types are not significantly different with respect to most of the policies supporting or constraining the research of the faculty that were asked for this study. The most differences are regarding pressure for applied outcomes and commercial results, with Old School and New School showing mixed results, and the Engaged Traditionalist type indicating higher pressure than the Reluctant Entrepreneur type. Work experience in industry and knowledge of commercial science processes is associated with a movement towards New School, but other background factors were not significant.

Although there is a significant association between discipline and type, there were both some expected and some surprising distribution patterns, yielding no clear alignment between the discipline and particular types—a result that probably says more about the broad-based nature of the transformation of academic science than it does about the validity of the typology. Thus it becomes difficult to construct a profile of each of the types, or to verify that the faculty falling into the types in this study mirror the descriptions of the pure types in the original theory.

Typology Classification

The next step in the typology analysis was to determine whether it provides any indication of mutually exclusive types that could be used for classification purposes and group comparisons in the regression models. Table 23 below reveals some low to moderate correlations between the four composite index scores for the type variables, using the groupings derived from the index preferences. Given that these are paired comparisons, if the types were indeed distinct, we should expect to see moderate to high negative correlations, so that as a person scores high on one, they should be lower on the other. The correlations observed here are moderate, and there are only two negative correlations, although interestingly, Old School—New School is one of these, as is Old School—Engaged Traditionalist. Others are positively correlated, and the Engaged Traditionalist-New School has a moderate positive correlation, possibly explaining the movement towards New School in the placement method comparison.

Table 23: Correlations of Type Indices

	Old School	Engaged Traditionalist	Reluctant Entrepreneur	New School
Old School	--			
Engaged Traditionalist	-0.34 **	--		
Reluctant Entrepreneur	0.25 **	0.06 *	--	
New School	-0.44 **	0.51 **	-0.01	--

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Graphical observation makes the case more clearly. Figure 5 on page 154 contains six graphs of the possible type pairings (these graphs are reproduced in Appendices 2 - 7). The intent is to observe how cases clustered together; a trend

toward distinct types would reveal clustering along the axes—with high values for one and low for another. The six graphs display cases in bins, with larger circles representing more cases. Also, fit lines are included to show the slope of the relationship. The actual numerical values on the graphs are not critical; the important item of focus is the clustering of the bin counts.

The graphs show further evidence of a lack of distinction between types. Instead, clustering occurs around the midpoints or the intersection of two types in each graph. The clearest distinction can be seen in the Old School—New School comparison, which has the negative correlation of -0.44. This provides some support for the theory, since it is these main-diagonal positions that are posited to be most directly opposed. The strongest positive correlation is for Engaged Traditionalist—New School, which is perhaps explained by each positions acceptance of the need for commercial activity.

The graphical analysis shows that it may be difficult to reliably place people into one type category. This could be because the type constructs are not as distinct as the theory would indicate, or it could be that the faculty in this study have preferences that fall across types, or that their preferences could be context-dependent. Since there is not a clear way to classify faculty respondents into one type, this could be evidence that faculty embrace values associated with multiple types.

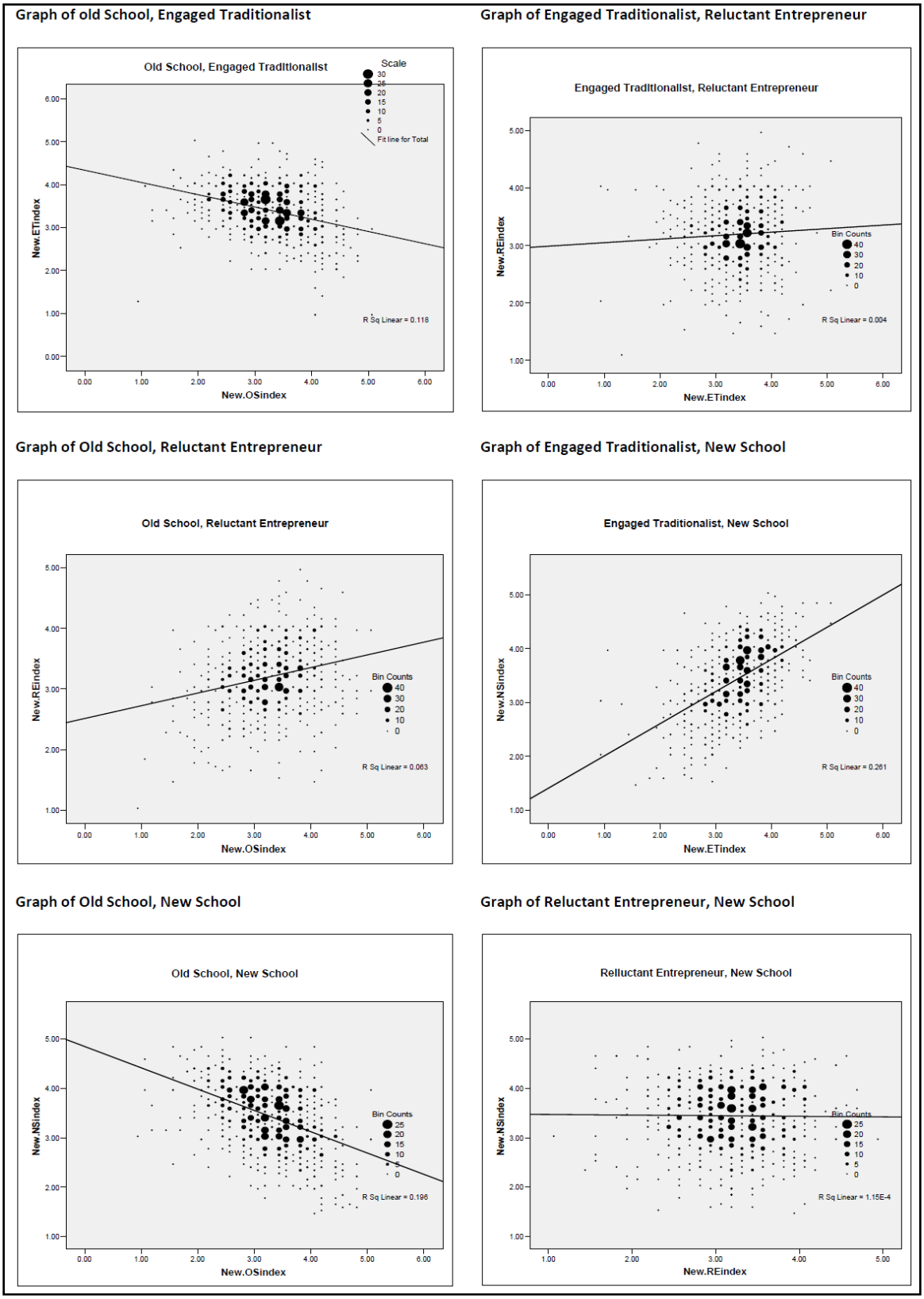

Figure 5: Graphical Analysis of Possible Paired-Type Comparisons

Another way to look at how the classifications of the typology theory do not match the complexity of the issues involved in commercial science is to examine how respondents rated the individual issues: funding, basic/applied research, publishing/ patenting, conflicts of interest/commitment, and criteria for good science. Table 24 on the next page summarizes the items rated highest, or that had the highest level of agreement, among the faculty of a given type.

The five primary rows represent the five issue questions (funding, etc.), and within each is an indicator for the questions written from the point of view of the types (see Table 16, p. 142). The middle columns are the faculty classified into one of the four types (using the indices), so each cell is the percentage of each faculty type who had the highest level of agreement with the questions that correspond to each viewpoint. The columns to the right depict the same data in terms of rankings, from highest to lowest levels of agreement. The bottom section summarizes how many times faculty of each type agreed with the question representing their own type first, second, third or fourth.

Table 24: Percentages and Rankings for Type Agreement on Issue Questions

Issue	Question Type	Faculty Type -Index Preferences Percentages: Old School	Engaged Traditionalist	Reluctant Entrepreneur	New School	Faculty Type -Index Preferences Rankings (High to Low): Old School	Engaged Traditionalist	Reluctant Entrepreneur	New School
Funding Issues	Old School	54.4%	13.1%	30.5%	13.2%	1	2	2	3
	Eng. Trad	41.8%	82.1%	60.2%	72.5%	2	1	1	1
	Reluctant Entr	3.2%	.8%	4.2%	.5%	3	4	4	4
	New School	.7%	4.0%	5.1%	13.7%	4	3	3	2
Basic-Applied Issues	Old School	16.2%	2.0%	4.1%	1.0%	3	3	4	3
	Eng. Trad	26.4%	49.0%	29.8%	16.0%	2	1	2	2
	Reluctant Entr	2.5%	.4%	9.1%	.5%	4	4	3	4
	New School	54.9%	48.6%	57.0%	82.5%	1	2	1	1
Publish-Patent Issues	Old School	62.9%	15.9%	18.3%	22.7%	1	2	3	2
	Eng. Trad	1.4%	3.3%	1.7%	1.8%	4	4	4	4
	Reluctant Entr	15.9%	14.6%	41.7%	9.7%	3	3	1	3
	New School	19.8%	66.1%	38.3%	65.8%	2	1	2	1
Conflicts Issues	Old School	25.8%	5.0%	13.3%	4.6%	3	4	3	4
	Eng. Trad	36.4%	57.1%	21.2%	41.2%	1	1	2	1
	Reluctant Entr	34.9%	32.1%	61.1%	30.2%	2	2	1	2
	New School	2.9%	5.8%	4.4%	24.0%	4	3	4	3
Success Issues	Old School	41.8%	4.0%	13.6%	6.2%	1	4	3	3
	Eng. Trad	8.0%	22.5%	10.2%	6.2%	4	2	4	3
	Reluctant Entr	22.0%	12.4%	22.0%	10.7%	3	3	2	2
	New School	28.2%	61.0%	54.2%	76.9%	2	1	1	1
				RANKING OWN TYPE:	1st	3	3	2	3
					2nd	0	1	1	1
					3rd	2	0	1	1
					4th	0	1	1	0

Similar to the comparison of the two classification schemes in Table 18 (p. 145), part of the story is in the main diagonals (like a correlation table), which have been highlighted for the rankings. This analysis does show some stability for the types. For each issue, faculty had the highest levels of agreement (ranked 1) with the question representing their own point of view twice, and this occurred three times for the 'publishing/ patenting' issue. The bottom summary presents how many times each type had ranked is associated issue question ranked 1st, and this occurred three times for every type except Reluctant Entrepreneur, which had two 1st rankings. Still, the rankings do not tell the whole story, as there are many large gaps between the percentages of faculty within various groups, so the ordering of agreement belies the disparity between types. Many types show large percentage drop-offs between 1st and 2nd, for example, which again speaks to some measure of inconsistency in the rankings.

Since there is not a reliable method to classify each faculty respondent into one type, additional analysis was performed to identify the preference orders the faculty express among the four types, again using their composite scores. There are 24 possible combinations of preference order, and each faculty respondent was placed into one of the combinations.

The analysis of patterns in the data reveals a distribution among all of them, rather than a clustering around just a few, and there were no combinations that remained unused. The results, sorted in descending order of occurrence, are shown in Table 25 below, with the first column presenting the top two preferences, and the middle column the bottom two preferences for each combination.

Table 25: Distribution of 24 Possible Type Preference Orders, with Sorting

Sorted Preferences Top 2	Sorted Preferences Bottom 2	Freq	Valid Pct
New School- *Engaged Traditionalist*	*Reluctant Entrepreneur*-**Old School**	165	15.5
New School- *Engaged Traditionalist*	**Old School**-*Reluctant Entrepreneur*	109	10.2
Engaged Traditionalist -**New School**	*Reluctant Entrepreneur* -**Old School**	87	8.2
Old School- *Reluctant Entrepreneur*	*Engaged Traditionalist* -**New School**	78	7.3
Old School- *Reluctant Entrepreneur*	**New School** -*Engaged Traditionalist*	54	5.1
Engaged Traditionalist -**New School**	**New School** -*Engaged Traditionalist*	53	5.0
Old School -*Engaged Traditionalist*	**New School** -*Reluctant Entrepreneur*	50	4.7
New School -*Reluctant Entrepreneur*	*Engaged Traditionalist* -**Old School**	44	4.1
Old School -*Engaged Traditionalist*	*Reluctant Entrepreneur* -**New School**	43	4.0
New School -**Old School**	*Engaged Traditionalist -Reluctant Entrepreneur*	41	3.8
Old School -**New School**	*Engaged Traditionalist -Reluctant Entrepreneur*	34	3.2
Engaged Traditionalist -Reluctant Entrepreneur	**Old School** -**New School**	31	2.9
Old School -**New School**	*Reluctant Entrepreneur- Engaged Traditionalist*	29	2.7
Engaged Traditionalist -**Old School**	**New School**- *Reluctant Entrepreneur*	28	2.6
Engaged Traditionalist -**Old School**	*Reluctant Entrepreneur* -**New School**	27	2.5
Engaged Traditionalist -Reluctant Entrepreneur	**New School** -**Old School**	26	2.4
New School -**Old School**	*Reluctant Entrepreneur -Engaged Traditionalist*	26	2.4
Reluctant Entrepreneur -**Old School**	*Engaged Traditionalist* -**New School**	25	2.3
Reluctant Entrepreneur-Engaged Traditionalist	**New School** -**Old School**	24	2.3
Reluctant Entrepreneur -**Old School**	**New School**- *Engaged Traditionalist*	22	2.1
Reluctant Entrepreneur -Engaged Traditionalist	**Old School** -**New School**	19	1.8
Reluctant Entrepreneur -**New School**	**Old School** -*Engaged Traditionalist*	19	1.8
New School -*Reluctant Entrepreneur*	**Old School** -*Engaged Traditionalist*	19	1.8
Reluctant Entrepreneur -**New School**	*Engaged Traditionalist* -**Old School**	12	1.1
Total		1,065	100.0

Note: **Primary types**; H*ybrid types*

Those with New School as a first preference make up 37.9 % of the faculty, with an additional 22% having New School as their second most-preferred. Those with Old School as a first preference area represent about 26.9% of the respondents, and another 15.9% indicate Old School as their second preference. Surprising also may be the 638 people with New School as a first or second choice, representing 60% of the sample, whereas 457, or 42%, have Old School in their top two preferences. Thus, Old School values and the conventional view of research are still very much present in the minds of faculty; however they are not the prevailing point of view.

The three highest frequencies are for the combinations that have New School and Engaged Traditionalist in the top two, representing 33.9% of the respondents. These are the faculty who share a belief that commercial science is not a threat to the academy. However, the next largest group (12.4%) is those who preferred the positions that do view commercial science as a threat—Old School and Reluctant Entrepreneur.

The occurrences of having one of the two hybrid positions as one of the top two are less frequent. Engaged Traditionalist is the first preference for 23.7% of these faculty, while 11.4% prefer Reluctant Entrepreneur first. Also, 11 of the bottom 13 groupings have one of the hybrid positions first, and four of these have both as the two most preferred. Reluctant Entrepreneur is the least preferred overall, as all six of its appearances in the first position occur in the bottom seven combinations. And while 10 of the first 12 combinations have a hybrid type in the top two, only three have it as the first position. Still, these patterns reveal that one of the hybrid position are legitimately preferred first by more than one-third of the sampled faculty (35%), showing that faculty with these values can do research at major universities.

Summary

The typology placement based on the indices presents a more complex understanding of the boundary between academic and commercial science than does just asking faculty about the threats from or overlap with industry. Faculty were not asked to place themselves into one of the types, but their rating of the dimensions produced a distribution indicating moderate threat from commercial science and a distinction between academic and industry. Given that the largest grouping was for the

Engaged Traditionalist type, followed by Old School, it was reasonable to conclude faculty believe traditional academic values can either be maintained in the face of any threat, or that the separate nature of academic and commercial science means that the academy as a whole will not be undermined by individual faculty engaging in such activity.

However, the two different classification procedures showed that placement via the indices reveals a shift in the distribution towards the New School perspective as first, whereas it was third initially. The picture emerging from this distribution is one of greater overlap between academic and commercial science and a lesser threat from commercial science. The inference would be either that academic values can be made to work alongside those from the commercial science culture, or that the normative structure of commercial science is simply part of the process for conducting academic science now. However, the continued prominence of Old School signifies the persistence of traditional values.

Based on the results presented here and other analysis that was undertaken, the faculty typology of academy-industry relations as measured in this study is not workable as a classification scheme to reliably differentiate amongst a pool of academic scientists. There does not appear to be sufficient distinction between the constructs defining each type to allow for clean placement of faculty into one type, especially for those that may exist on the theoretical border between two types. Combined, these findings seem to indicate that the value systems faculty bring into sponsored research activity could be multiple, overlapping, and context-dependent.

With respect to examining group differences among faculty types, the analysis was dependent upon the type constructs themselves being distinct enough to produce a reasonable classification, and that the constructs would be sufficiently well-defined so that the faculty indicating a preference as one of the types would have beliefs that distinguished them from faculty in the other types. Hence, there does not appear to be a reliable way of assigning particular background characteristics to the types for any predictive purposes.

Dependent Variables: Measures of Control (Res Q's 1 & 5)

Based on the review of the literature, faculty should exhibit some differences in their perceived sense of control by academic discipline and source of support for their research. Also, it is theorized that there will be some differences between faculty types, so the analysis here will also test the academy-industry typology offered by Owen-Smith and Powell (2001). Before that, however, the control scenarios (Four Cs) are examined.

Control Scenarios (Four Cs)

First are the results from the theoretical scenarios for control and sponsor relations—Curiosity, Collaboration, Compromise, & Concession (see Table 2, p. 102). Respondents were asked to rate the frequency of occurrence of four different scenarios regarding control over their topic choices, in relation to sponsorship from both government and industry. In all four cases, higher scores indicate higher control. Given

that the first two outcomes in Pairs 1 and 2—Curiosity and Collaboration—involve scenarios in which faculty can obtain funding for their interests or negotiate with sponsors to get most of what they seek, these can be referred to as affirmative measures of self-direction. The other two outcomes in Pairs 3 and 4—Compromise and Concession—involve negative scenarios in which limiting restrictions or overcoming interference from sponsors is desired, rather than having to compromise research topics or concede one's interests. Higher scores here indicate higher levels of freedom from interference and other hindrances, thus resulting in greater control.

The mean comparisons for the four paired scenarios for government and industry funding are displayed in Table 26 below. Based on this data, overall the faculty respondents feel they retain more control or have greater freedom from interference when receiving sponsorship from government agencies. In three of four cases, the means are significantly higher for government funding. The values as a whole also suggest that freedom from interference is more likely to indicate greater control as respondents indicate higher values (less frequency of occurrence) for Compromise and Concession; measures for self-direction, as expressed here in the Curiosity measure, score moderately high on control, indicating that topic selection based solely on faculty interests happens more often than just 'Occasionally'.

The scores for industry funding also indicate that interference (Pairs 3 and 4) is a less common occurrence—and thus results in higher control scores—than does either of the self-direction measures in Pairs 1 and 2, Curiosity and Collaboration. The control score for Curiosity and industry funding (2.22) is the lowest among the eight items

measured here, indicating that faculty only rarely feel they can be self-directed in their topic choice when getting industry sponsorship. However, given that industry generally has specific objectives for its research sponsorship, this should not be surprising.

Table 26: Results from Paired T-Tests of Four Theoretical Scenarios for Sponsor Relations

		Mean	SD	t	df	Sig.
Pair 1	CURIOSITY: Government funding Able to obtain funds solely on my interests	3.31	1.13			
	CURIOSITY: Industry-Corporate funding Able to obtain funds solely on my interests	2.22	1.21	23.17	799	0.00
Pair 2	COLLABORATE: Government funding Agree on topics of mutual interest	2.72	1.38			
	COLLABORATE: Industry-Corporate funding Agree on topics of mutual interest	2.72	1.55	0.05	779	0.96
	Note: 1= Never, 2=Rarely, 3=Occasionally, 4=Usually, 5= Always					
Pair 3	COMPROMISE: Government funding Yield some aspects of topic selection	3.62	1.39			
	COMPROMISE: Industry-Corporate funding YIELD SOME ASPECTS OF TOPIC SELECTION	3.51	1.48	2.51	754	0.01
Pair 4	CONCESSION: Government funding Accede to sponsor influence to get funds	3.88	1.24			
	CONCESSION: Industry-Corporate funding Accede to sponsor influence to get funds	3.61	1.44	6.35	726	0.00
	Note: 1=Always, 2=Usually, 3=Occasionally, 4=Rarely, 5=Never					

Note: Higher scores indicate higher self-perceptions of control

It is also possible to examine the differences for the scores within a funding type according to kind of control they indicate. Remembering that two constructs—Curiosity and Collaboration—are affirmative aspects of control indicating self-direction, and the other two outcomes—Compromise and Concession—are negative definitions in which higher scores indicate overcoming sponsor interference, Table 27 below presents comparisons of these combinations within each funding type. Within each pair, the upper item is the affirmative construct, and the lower one is the negative construct.

In all eight of these comparisons, the mean for the lower item (the adverse outcome) is higher than that of the upper item (the affirmative outcome), and the mean difference is significant for every paired test. This would mean that faculty express a greater sense of control when control is defined as freedom from adverse influences of sponsors on their research agendas. Thus, the faculty feel more secure about not being interfered with by their sponsors than they do about having complete or mostly-complete autonomy from them.

Table 27: Results from Paired T-Tests of Positive and Negative Control Scenarios

		Government-Agency Funding				
		Mean	SD	t	df	Sig.
Pair 1	CURIOSITY	3.47	1.10			
	COMPROMISE	3.67	1.38	-4.21	1038	0.00
Pair 2	CURIOSITY	3.47	1.10			
	CONCESSION	3.95	1.22	-10.74	1020	0.00
Pair 3	COLLABORATE	2.66	1.39			
	COMPROMISE	3.67	1.38	-14.52	1026	0.00
Pair 4	COLLABORATE	2.67	1.39			
	CONCESSION	3.94	1.21	-19.37	1010	0.00
		Industry-Corporate Funding				
		Mean	SD	t	df	Sig.
Pair 1	CURIOSITY	2.27	1.22			
	COMPROMISE	3.51	1.48	-17.12	750	0.00
Pair 2	CURIOSITY	2.28	1.22			
	CONCESSION	3.61	1.44	-18.94	728	0.00
Pair 3	COLLABORATE	2.73	1.55			
	COMPROMISE	3.51	1.48	-8.19	759	0.00
Pair 4	COLLABORATE	2.75	1.55			
	CONCESSION	3.61	1.44	-9.24	735	0.00

Note: Higher scores indicate higher self-perceptions of control

To delve into these control scenarios a little more deeply, the next table presents the results of one-way independent ANOVAs, testing for group differences by academic discipline (Table 28 below, p. 166). Several things stand out when considering the group differences. Engineering, for example, is significantly different from at least one other discipline in all but one comparison (Curiosity-industry), and in many cases, more than one. Also, engineering presents some interesting circumstances; in the upper half of the table which presents the two affirmative scenarios exhibiting self-direction, it has the highest score for Collaboration for both forms of sponsorship, but is fourth for Curiosity with government sponsorship. However, for both measures of freedom from interference, engineers present the lowest scores (the lowest control) in all cases.

Social scientists present interesting extremes; they express most of the lowest scores for the self-direction measures, Curiosity and Collaborate—and understandably, with industry funding—but indicate the highest levels on the four measures of freedom from interference—Compromise and Concession—regardless of funding source. Meanwhile, the medical, physical, and biological science respondents all indicate moderate and moderately low levels of self-direction, with Curiosity-government being the highest rated scenario, but with Collaboration scoring higher overall. The medical, physical, and biological science disciplines each present moderately-high to high scores on the measures of freedom from interference, with Concession being the rarest scenario. Perhaps engineers tolerate these more restrictive scenarios as part of their work, as they express the lowest control scores for these scenarios, but in any case, they recognize them.

Table 28: Mean Scores on Control Scenarios, by Academic Discipline

	Engineering (all types)		Medical/ Health Sciences		Physical Sciences		Biological Sciences		Social Sciences		ANOVA	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F	η^2
Affirmative scenarios: self-direction, autonomy												
CURIOSITY: Government	$3.30_{a,b,c}$	1.03	3.40	1.15	$3.63_{b,d}$	1.02	$3.64_{c,e}$	1.03	$3.25_{d,e}$	1.22	5.89 ***	0.02
CURIOSITY: Industry-Corp	2.31	1.07	$2.56_{a,b,c}$	1.30	2.02_{a}	1.09	2.15_{b}	1.22	2.02_{c}	1.23	6.62 ***	0.03
COLLABORATE: Government	$3.16_{a,b,c}$	1.22	2.57_{a}	1.39	2.85_{d}	1.44	2.57_{b}	1.40	$2.37_{c,d}$	1.35	9.01 ***	0.03
COLLABORATE: Industry-Corp	$3.62_{a,b,c,d}$	1.29	$2.46_{a,e}$	1.45	$2.86_{b,f}$	1.63	$2.82_{c,g}$	1.53	$2.01_{d,e,f,g}$	1.39	24.92 ***	0.11
Note: 1= Never, 2= Rarely, 3= Occasionally, 4= Usually, 5= Always												
Negative scenarios: restriction, interference												
COMPROMISE: Government	$3.17_{a,b,c,d}$	1.21	3.68_{a}	1.48	3.66_{b}	1.38	3.76_{c}	1.38	3.95_{d}	1.28	7.68 ***	0.03
COMPROMISE: Industry-Corp	$2.66_{a,b,c,d}$	1.27	3.76_{a}	1.48	$3.43_{b,e}$	1.50	$3.44_{c,f}$	1.47	$4.15_{d,e,f}$	1.24	22.08 ***	0.10
CONCESSION: Government	$3.43_{a,b,c,d}$	1.29	3.93_{a}	1.24	4.03_{b}	1.17	4.00_{c}	1.21	4.20_{d}	1.07	9.85 ***	0.04
CONCESSION: Industry-Corp	$2.80_{a,b,c,d}$	1.31	3.91_{a}	1.35	$3.57_{b,e}$	1.45	$3.50_{c,f}$	1.50	$4.19_{d,e,f}$	1.21	20.94 ***	0.10
Note: 1=Always, 2=Usually, 3=Occasionally, 4=Rarely, 5=Never												

Note: Means sharing subscripts within a row are significantly different. *** = $p < .001$
Higher means indicate higher levels of control in all cases.

Even though some groups express high or low scores relative to others, it should be noted how infrequently faculty expressed extremely high levels of self-direction or freedom from interference. For the two self-direction measures—Curiosity and Collaboration—there are no group means at 3.70 or higher; most of the scores are between 2.0 and 3.0. On the measures regarding restriction and interference—Compromise and Concession—the scores are generally higher, with only two scores for engineering being below 3.0. However, just five of the 20 scores here are above 4.0, with social scientists falling between "Rarely "and "Never" three times. Meanwhile faculty from the biological and physical sciences each scored above 4.0 in the area of Concession-government.

Table 29 below (p. 168) displays the mean score comparisons by the faculty type variable being tested in this study. Only three of the eight scenarios have significant differences between the types: Curiosity-industry and the two Collaborate scenarios. The two types on the main diagonal of Table 1 and Figure 3—Old School and New School—are significantly different, and have the highest mean differences for the three measures. Old School is also significantly different (and rates lower) from Engaged Traditionalist in each scenario, but has no significant differences from Reluctant Entrepreneur. Given the low scores, it would also appear that Old School faculty generally perceive the least amount of control regarding Curiosity and Collaboration. Also, in accordance with the theory, New School faculty express higher scores in scenarios involving industry funding, but they also are significantly higher regarding collaboration involving government agencies.

Table 29: Mean Scores on Control Scenarios, by Faculty Type

	Old School		Engaged Traditionalist		Reluctant Entrepreneur		New School		ANOVA	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F	η^2
Affirmative scenarios: self-direction, autonomy										
CURIOSITY: Government	3.59	1.07	3.40	1.13	3.47	1.09	3.39	1.09	2.01	0.006
CURIOSITY: Industry-Corp	$1.89_{a,b}$	1.11	2.27_{a}	1.16	2.27	1.29	2.37_{b}	1.22	6.25***	0.024
COLLABORATE: Government	$2.34_{a,b}$	1.40	2.81_{a}	1.33	2.61	1.45	2.82_{b}	1.39	7.33***	0.022
COLLABORATE: Industry-Corp	$2.33_{a,b}$	1.55	$3.11_{a,c}$	1.55	$2.30_{c,d}$	1.50	$2.84_{b,d}$	1.51	10.24***	0.040
Note: 1= Never, 2= Rarely, 3= Occasionally, 4= Usually, 5= Always										
Negative scenarios: restriction, interference										
COMPROMISE: Government	3.77	1.39	3.56	1.35	3.60	1.48	3.67	1.38	1.06	0.003
COMPROMISE: Industry-Corp	3.53	1.59	3.41	1.42	3.64	1.55	3.53	1.43	0.47	0.002
CONCESSION: Government	4.07	1.21	3.93	1.16	3.87	1.27	3.88	1.25	1.38	0.004
CONCESSION: Industry-Corp	3.52	1.56	3.44	1.47	3.71	1.49	3.72	1.35	1.61	0.007
Note: 1=Always, 2=Usually, 3=Occasionally, 4=Rarely, 5=Never										

Note: Means sharing subscripts within a row are significantly different. *** = $p < .001$
Higher means should be interpreted as higher levels of control in all cases.

The hybrid positions only have one significant difference with each other—on Collaborate-industry, with Engaged Traditionalist having the highest score of any type for this scenario. The Engaged Traditionalists—those who view commercialization as something that can be done in moderation without damaging academia as a whole—report a higher frequency of collaboration with research sponsors for government funding than do Reluctant Entrepreneurs. For their part, Reluctant Entrepreneurs, who view commercial activity as an unfortunate necessity, perceive significantly less control than do New School faculty.

The lowest set of scores observed is for Curiosity-based research with industry funding, with results hovering around the "Rarely" range, and Old School faculty seem to have the lowest perceptions of self-direction in the three scenarios with meaningful group differences. In general, the scores for the four self-direction measures are lower than for the freedom from interference ones, however, there are no significant group differences in the bottom half of the table.

Regression Models (Four Cs)

Table 30 below (p. 170) summarizes the results from regression models estimated for all eight of the control variables discussed here. The full details of each model can be found in Appendices 8 – 15. Gender was only significant once—a positive association with Compromise for industry funding. The career variables had only a few significant associations, and all were for government funding: the long time academics have a boost in Curiosity, relative to those in academia 7 years or less, and those with 8-15 years have higher control scores for Compromise and Concession. Perhaps those in

mid-career can exercise more direction than their junior colleagues, while the most senior faculty simply have to give up less. 'Years in industry' has two positive associations for Collaboration-government, but negative for Concession for those with the most experience.

Table 30: Summary of Eight Regression Models, Four Cs for Both Funding Sources

	Curiosity		Collaboration		Compromise		Concession	
	Gov't	Ind	Gov't	Ind	Gov't	Ind	Gov't	Ind
DEMOGRAPHICS								
Gender						+		
CAREER								
8-15 Years in academia *(Ref = 0 -7)*					+		+	
16-24 Years in academia								
25-plus Years in academia	++							
Less than 1 Yr worked -Industry *(Ref= None)*								
1 to 5 Yrs worked in industry			+					
6-plus Yrs worked in industry			+				– –	
COMMERCIAL SCIENCE INVOLVEMENT								
Knowledge of Commercialization			+++	++	–	–	–	–
Highest Involvement in Commercial Science								
1 Commercial Science activity *(Ref = None)*						–		
2 Commercial Science activities				++		–		
3 Commercial Science activities		++		+				
4-plus Commercial Science activities		++		+++		– –		
INSTITUTIONAL CS ENVIRONMENT								
Pressure Select topics with commercial potential							– –	– –
Pressure: Focus on applied outcomes	–				–	–		
Pressure: Commercialize research results						– –		
Pressure: Limit publication of results			+					
Pressure: Generate revenues from my research	– –							
My academic institution:								
Has entrepreneurial environment								
Requires salary offset w external funds	++				– –		– –	
Provides financial support for my research	+			+			+	
Has policies to restrict publication of results		+					–	
Has procedural support for licensing/patents								
Has policies to resolve conflicts of interest								
Rewards commercial science activity in P & T				– –				
SOURCE OF SUPPORT								
Current sponsorship: Government-Public	+++	–						
Current sponsorship: Industry-Corporations	–	++		+++				
Current sponsorship: Foundations								
Current sponsorship: University						+		+
Current sponsorship: Other	–		–	–		+		
FACULTY TYPE PREFERENCES								
Old School						–		
Engaged Traditionalist						–		–
Reluctant Entrepreneur					– –		– –	
New School		+	++					

	Curiosity		Collaboration		Compromise		Concession	
	Gov't	Ind	Gov't	Ind	Gov't	Ind	Gov't	Ind
ACADEMIC DISCIPLINE (Ref = Social Science)								
Engineering				++		−−−		−−−
Medical/ Health Sciences		++						
Physical Sciences								
Biological Sciences	+			+				
INSTITUTIONAL TYPE (Ref = Very High Research Act)								
Type-High research activity								
Type – Doctoral/Research Univ								
Control *(Ref = Public)*								
Research Expenditures (Pctg.)								
Federal Government								
State Government				+				
Industry				+				
Institutional Funds								
R^2	0.163	0.131	0.142	0.265	0.130	0.196	0.169	0.194
Adjusted R^2	0.131	0.098	0.109	0.237	0.096	0.165	0.136	0.163
Standard Error	0.980	0.939	1.225	1.094	1.218	1.074	1.040	1.028
F	5.053	3.914	4.293	9.237	3.864	6.300	5.244	6.245

Note: (+ = p < .05, ++ = p < .01, +++ = p < .001); − = p < .05, −− = p < .01, −−− = p < .001)

Regarding commercial science involvement, 'knowledge of commercialization' was theorized to have a positive association with control, in that those who knew more about the process would feel greater control over their research, but for this data, it was not the case. Collaboration with self-reported government and industry funding sources were positive; Compromise and Concession were both negatively associated with control for both sponsorship types. Level of involvement with an invention had no significant associations. Involvement with commercial science activities had significant associations only for industry funding; 'number of commercial science activities' had positive associations for Curiosity and Collaborate, but were negative for Compromise.

Moving to the institutional environment for commercial science, the pressure or constraints had largely negative associations—as would be expected—except for one instance: limitation of publications for Collaboration with government funding. Perhaps

the negotiated status of collaborative research partnerships allows faculty to accept such restrictions.

The effects of institutional policies were varied. Three variables had no significant effects: having an entrepreneurial environment, policies to support licensing and patenting, and policies to resolve conflicts. Requiring salary offsets from sponsorship was positive for Curiosity-government, but negative for Compromise and Concession with government sponsors, which may indicate an exacerbation of having to give up some control in the first place. Receiving institutional financial support was positive in three models—a finding that makes intuitive sense—while policies to restrict publication had one positive and one negative association, with the positive one somewhat surprising. Having commercial science rewarded for promotion and tenure had one negative association for Collaboration-industry.

Source of support is also mixed, with government support split in the Curiosity models, suggesting the perception of such funding is situational. Industry support is positively associated with Curiosity and Collaboration with industry funding, but is negative for Curiosity with government funding. University support was positive for Compromise and Concession with industry funding. Perhaps receiving these in-house funds provides some offset to the feeling of lesser control in these two circumstances.

Each faculty type had at least one significant relationship across the eight models, although not as many instances as might be expected. Three types—Old School, Engaged Traditionalist, and Reluctant Entrepreneur—had only negative associations, and all were for the Compromise and Concession models. Each of those

three types retains some conventions of academic science in its traditional form, so it not unreasonable to expect that faculty with those preferences would feel some loss of control with sponsors having stringent demands for their research. Conversely, the type position most in accord with the legitimacy of sponsor negotiations—New School—had only positive associations: one each with Curiosity, Collaborate, and Concession.

Academic discipline was also mixed. Relative to social science faculty, engineering emerged as significant for three models with industry funding: positive for Collaboration and negative for Compromise and Concession. With engineering faculty being more accustomed to working with industry partners, those scenarios where some control is lost may not be as bothersome as they might be for other disciplines. Medicine only emerged as positive for Curiosity-industry, indicating that these faculty may be able to find industry partners that share their interests, or allow them greater latitude. Biology had two positive associations for Curiosity and Collaborate, indicating they feel better about control of their research with government funding, but can find workable situations with industry support. The physical sciences had no significant associations.

Institutional type and control type has no significant effects, suggesting that where a faculty is situated does not affect the personal sense of control one has or should have, but could also mean that all faculty are similarly affected by the competitive environment for research funds, and not just those at large publics doing high volumes of research. Research expenditures at the institutional level by source of

funds were only positively associated with Collaboration-industry in two instances—state government and industry funds.

Finally, as a whole, these models explain modest amounts of the variance of their dependent variables, with adjusted R^2 values ranging from just under 10% to 23%. The adjusted R^2 values are unbiased estimators of the variance that would be explained by the models for the entire population. The large number of predictors in the model increases the possibility of an inflated R^2 value since most independent variables will have some correlation with the outcome variable. Thus, the model is penalized for having predictors that account for little vaiation beyond that already explained by the important predictor variables. With the low values for the shrunken R^2 values, it would seem that the model has too many predictors that do not explain meaningful amounts of variance (Archdeacon, 1994; J. Cohen, Cohen, West, & Aiken, 2003).

Summary

The control scenarios involving different funding contexts were important because all faculty are not in the same position regarding sponsor relations because of differences between government and industry funding. For all but one of the paired control scenarios tested, the level of perceived control was higher for government funding than for industry funding. There were group differences in every control scenario for the different academic disciplines, but only for three of the scenarios when grouping faculty by their theorized type. This adds to the evidence for lack of distinction among the types.

Also, faculty indicate that their relations with sponsors are not as contentious or restrictive as the literature about industry funding might argue. For all scenarios, higher scores indicate higher control, but it is important to reiterate that the second set of pairs—Compromise and Concession—define negative scenarios that constitute interference or constraint, and higher scores mean less frequency of occurrence, and thus, increased control. The means for all four of these scenarios were significantly higher than were those for the Curiosity and Collaborate pairings, which were defined as positive scenarios indicating control and self-direction.

There is considerable variability in the important predictors for each of the eight models. Except for the Curiosity scenarios, the models explained more variance for the industry funding scenarios than for the government funded ones. Among the important theorized predictors, career variables measuring experience were only significant for government funding, while commercial science knowledge was significant for six of the eight models. Involvement in commercial science activities were only significant for industry funding, which may be a natural artifact of the data and sample; those not getting industry funding might not be involved in commercial science to any meaningful extent.

The variables concerning institutional pressures for commercial science were negative in every case when significant, except one, while institutional policies regarding commercial science were mixed in their effects. Sources of support seem more important for industry funding than government, as two government models have no significant associations at all, while all four industry models have at least one. Regarding

the faculty types, both government and industry funding have one model with no significant predictors. Government scenarios saw New School emerge once and Reluctant Entrepreneur twice. Industry funding has all types except Reluctant Entrepreneur emerge at least once, and has five overall. Finally, no disciplines were significant in three of the four government models, but at least one was in all four industry models. Research expenditures were only significant in one industry model for Collaboration.

Control Over Research Agenda (Res Q's 1, 4 & 5)

Original Scale for Control

Moving to analysis of the primary dependent variable, Table 31 below (p. 177) summarizes the means for the 12 items developed for the Control scale. These were originally coded on a frequency scale ranging from 1=Always, 2=Usually, 3=Occasionally, 4=Rarely to 5=Never. For items 1, 4, and 8, the scale was reversed to make Always = 5 so that higher scores would indicate higher control. The resulting scores can consistently be interpreted as lower values meaning lower control, less freedom, or more hindrances, and higher scores indicating higher levels of control, or greater levels of freedom from restrictions and ability to overcome interference.

These means suggest moderate to high levels of control, and indicate that these faculty believe the positive aspects of control occur somewhere between "Occasionally" and "Usually", while the negative aspects of interference or hindrance occur only "Occasionally" or "Rarely". From these scale items, three separate variables were

created for the study to capture faculty perceptions of their ability to control their research agenda.

Table 31: Descriptives for Control Scale Items

		Mean	SD	N
1	I am able to find research funding for the questions I wish to pursue	3.41	0.81	1088
2	Sponsors of research actively attempt to influence my choice of research topics	3.54	1.09	1067
3	Inability to find funding keeps me from pursuing the problems of greatest interest to me	3.15	1.02	1081
4	I am able to fit my research questions into the project goals of my funding providers	3.59	0.79	1057
5	I alter the focus of my research to accommodate the project goals of my research sponsors	3.28	1.08	1066
6	Researching topics of interest to my research sponsors keeps me from studying topics important to me	3.83	0.99	1070
7	My research sponsors have specific problems they want me to research for them	3.50	1.23	1047
8	I convince research sponsors that my research questions will advance their interests	3.06	1.13	1039
9	I have to compromise my research interests in order to secure funding for any research	3.72	1.14	1057
10	Research sponsors ask me to make my research more commercial	4.40	0.87	1051
11	I am concerned that my commercial activity will compromise my ability to conduct objective science	4.46	0.96	1029
12	I am restricted from conducting basic research with the funding I am able to raise	3.94	1.21	1038

Note: 1 = Low Control, 5= High Control

Based on the data reduction conducted in chapter 3, there are three outcome variables for control over research agendas. First, is the one factor scale that emerged— "Self Directed Research" (see Table 4). This variable will also be examined for group differences. The other two variables are derived from single items in the original scale: Question 1 is "*I am able to find research funding for the questions I wish to pursue*" and Question 11 is "*I am concerned that my commercial activity will*

compromise my ability to conduct objective science." All three variables are on a 5-point scale, with higher scores equating to higher control.

Group Differences

The primary dependent variable "Self-Directed Research" is measured as a composite of the seven items from the factor, using an averaging of the original scores for each respondent to produce a single score. The analysis of this variable begins with determining what differences exists between groupings within some of the independent variables. Beginning with the personal/career variables, one-way analysis of variance tests revealed a few significant differences, although tenure, academic rank, and years as an academic were not among them.

In a surprising finding, female faculty (M=3.64, SD=0.82) have significantly higher perceived self-direction (t (1087) = -3.36, p =.001, 2-tailed) than their male counterparts (M=3.47, SD=0.83). Female faculty were oversampled because of their relative lack of representation in the science disciplines as a whole, so it was notable that gender would have this effect, given the established challenges facing women in the sciences. Perhaps owing to these challenges, the female scientists at these institutions have to be driven to succeed and direct their work with greater self-efficacy than male faculty.

Significant differences were observed for faculty grouped by their years of work experience in industry, F (3, 1082) = 8.50, $p < .001$, (Table 32 below). Those indicating they had never worked in industry (3.67) had a significantly higher level of self-direction regarding their research than both the group having worked 1 to 5 years and those

indicating six or more years of industry experience. The effect could be attributable to those working in industry accepting the trade-offs that come from partnering with corporations for research projects, or a real sense by those with no industry experience that their research sponsorship provides greater latitude.

Table 32: Means, Standard Deviations, and ANOVA, Self-Direction and Industry Work

	Never		Less than 1 yr		1 to 5 yrs		6 plus yrs	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Self-direction	$3.67_{a,b}$	0.81	3.46	0.84	3.38_{a}	0.84	3.44_{b}	0.83

Notes: Means sharing a subscript are significantly different. Effect size: $\eta^2 = 0.02$
Higher scores indicate higher control.

As was posited, there were significant differences noted in the level of perceived self-direction by academic discipline, F (4,1084) = 30.75, $p < .001$, (Table 33 below). Engineering has the lowest level of indicated control (2.97), and this value is significantly different from the other four disciplines. Given their frequent alignment with industry, some loss of autonomy could simply be an accepted part of their research work.

Table 33: Means, Standard Deviations, and ANOVA, Self-Direction and Discipline

	Engineering (all types)		Medical/ Health Sciences		Physical Sciences		Biological Sciences		Social Sciences	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Self-direction	$2.97_{a,b,c,d}$	0.71	$3.64_{a,e}$	0.77	$3.58_{b,f}$	0.80	$3.56_{c,g}$	0.85	$3.86_{d,e,f,g}$	0.78

Note: Means sharing a subscript are significantly different. Effect size: $\eta^2 = 0.10$.
Higher scores indicate higher control

Conversely, social science has the highest level of indicated self-direction (3.86) with a value that also differs significantly from the other four disciplines. With the lowest amounts of sponsored research funds among these disciplines, perhaps these faculty feel greater self-direction despite or because of their relative lack of funding.

Finally, there is no indication of any meaningful differences between the medical, physical, and biological sciences.

Turning to institutional characteristics, there was no statistical difference for self-direction between faculty at the three different institutional types in the study--research universities with "very high" or "high" research activity, and doctoral/research universities. However, control type did yield a meaningful difference. Faculty at public universities ($M=3.52$, $SD=0.83$) indicate a lower level of self-direction than do their counterparts at private universities ($M=3.75$, $SD=0.79$), $t(1086)= -3.73$, $p<.001$. This observation could be due to the changing nature of research funding at public universities in recent decades, whereas faculty at private universities could be more accustomed to securing sponsorship.

Faculty were also grouped according to variables concerning research funding by sponsorship type. First was an analysis based on research support at the level of the institution. Faculty were grouped in quintiles according to the percentage of sponsorship at the level of the home institution that came from federal funds and the percentage coming from industry funds. One-way analysis of variance tests were conducted, but neither of these main effects were significant for level of perceived self-direction based on funding type at the institutional level.

However, groupings according to self-reported support percentages (from the survey data) by source did reveal important differences. Faculty had been asked to indicate what percentage of their own research support came from different funding sources, and groupings were created for "public funding" and "industry." First,

regarding public or government funding (Table 34 below), those indicating 'no funding' were placed in a group, and those with any value greater than zero were placed into quintiles. These six groups had homogeneous variance in the ANOVA, and the main effect of this grouping was significant, $F(5, 1083)=6.99$, $p< .001$. The effect size was small, explaining 3% of the variance.

Table 34: Means, Standard Deviations, and ANOVA, Self-Direction and Public Support

	None		1 to 49%		50 to 75%		76 to 89%		90 to 99%		100 %	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Self-direction	3.78 $_{a,b,c,d}$	0.84	3.43 $_{a}$	0.78	3.40 $_{b,e}$	0.79	3.48 $_{c}$	0.85	3.53 $_{d}$	0.81	3.65 $_{e}$	0.84

Note: Means sharing a subscript are significantly different. $\eta^2= 0.03$; Higher scores indicate higher control.

The highest level of self-direction was for those faculty indicating they received no public money at all from any government funding (3.78). This group's mean was significantly different from every other group except for those indicating 100% government support for their research. The finding that receiving either none or all of one's research support from the government makes no difference regarding self-direction is surprising, suggesting two different reasons to have similar notions of control over one's research agenda. Also, the group indicating 50-75% of its support from the government had significantly lower self-direction than did those with 100% government funding support, although this could be an artifact of the distribution.

Group differences were also analyzed for percentage of research support from industry funding (Table 35 below). Homogeneous variance was observed for these three groups, and the main effect of industry funding was significant. The highest level of control was for the group with no industry funding (3.70), with the mean differences

between this group and the other two being statistically significant. The effect is also a medium-level effect size, with the main effect explaining almost 9% of the variance. These data provide another example of how receiving industry sponsorship lowers this perception of autonomy, but it could suggest that faculty in this position have a more nuanced conception of autonomy than has been captured.

Table 35: Means, Standard Deviations, and ANOVA, Self-Direction and Industry Support

	None		1 to 24%		25 to 100%		ANOVA	
	Mean	SD	Mean	SD	Mean	SD	F (2, 1086)	η^2
Self-direction	$3.70_{a,b}$	0.80	3.19_{a}	0.78	3.07_{b}	0.77	52.63***	0.088

Note: Means sharing a subscript are significantly different. Higher scores indicate higher control.

An important aspect of the conception of control that faculty perceive could be the knowledge they already have of the processes involved in commercial science. One survey question inquired specifically about this and faculty were placed into four groups based on the distribution among the responses. Analysis of variance was performed; these four groups had homogeneous variance and the main effect of commercial science knowledge was significant.

Table 36 below summarizes the main effect for level of commercial science knowledge, F (3,1070) = 29.95, $p < .001$. The highest level of self-direction is indicated by those faculty reporting no commercial science knowledge (3.93), and this level is significantly higher than the other three groups. Interestingly, those reporting the highest level of knowledge had the lowest perceived self-direction regarding their research (3.24), and the level was significantly different from those with no knowledge or 'vague' knowledge. In fact, there seems to be a negative association between 'commercial science knowledge' and self-direction, as greater knowledge indicates

lower control. Indeed, 'reasonable' knowledge rates lower than 'vague' for self-direction. It could be that the increasing understanding of the commercial science process entails some acceptance that autonomy will not be absolute, similar to those in the Reluctant Entrepreneur type.

Table 36: Means, SD, and ANOVA, Self-Direction and Commercial Science Knowledge

	None		Vague		Reasonable		Substantial/ Sophisticated	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Self-direction	3.93 $_{a,b,c}$	0.78	3.55 $_{a,d,e}$	0.78	3.29 $_{b,d}$	0.83	3.24 $_{c,e}$	0.84

Note: Means sharing a subscript are significantly different. Effect size: η^2 =0.08.
Higher scores indicate higher control.

Finally, to answer the fourth research question, the level of perceived self-direction was compared across the four faculty type preferences. The means for the types were all clustered between 3.50 and 3.69, but the results from the one-way ANOVA failed to show a significant main effect for faculty type, F (3, 1056) =2.37, p = 0.69. The results provide more evidence that they type theory does not produce groupings with sufficient distinction, as this result would indicate that all four types of faculty have similar perceptions of control, despite the theorized disparateness of their views regarding academic science.

Regression Models

To gain a more complete understanding of the factors that contribute to perceived levels of control regarding one's own research, the dependent variables created from the factoring of the control scale was regressed on the complete set of

independent variables. The results from the regression analyses are reported in Tables 38 – 40 below.

The first dependent variable is *Self-directed Research*, comprised of seven items as described in Table 4. The model, as presented in Table 37 below (p. 185), fits the data ($F=14.47$, $p <.001$) and explains nearly 36% of the variance for this item. Surprisingly, the career measures used here were not observed to be significant predictors, at any level. Thus, there is no advantage to experience in terms of years as an academic relative to junior faculty, nor does having industry work experience contribute significantly to control over research, relative to having none at all.

Another set of variables theorized to have some effect would be involvement in and knowledge of commercial science practices and processes. In this model, increased knowledge has a significant negative association with 'self-directed research,' similar to what the group differences indicate. This finding could suggest that the awareness of commercial science processes causes a redefinition of control that includes an understanding that some "pure" sense of control is lost. Moderate involvement in commercial science activities also has a negative effect on control here, and the result could suggest a similar phenomenon.

Several important predictors were observed to have negative effects on the amount of self-direction a respondent would perceive. Four of the five variables measuring institutional pressure for commercial science outcomes have significant negative associations with control. Since these are constraints, this result is not unexpected. An institutional policy requirement to offset one's own salary through

external research funds has a slight negative effect on self-direction, whereas receiving university support has a positive association.

Table 37: Regression Results for Model Predicting Self-Directed Research

	B	SEB	Beta	Sig.	
DEMOGRAPHICS					
Gender	.069	.044	.043	.121	
CAREER					
8-15 Years in academia *(Ref = 0 -7)*	-.005	.053	-.003	.920	
16-24 Years in academia	-.063	.056	-.035	.259	
25-plus Years in academia	-.015	.060	-.008	.799	
Less than 1 Yr worked in Industry *(Ref= None)*	.039	.072	.014	.591	
1 to 5 Yrs worked in industry	-.066	.052	-.032	.211	
6-plus Yrs worked in industry	.011	.060	.005	.849	
COMMERCIAL SCIENCE INVOLVEMENT					
Knowledge of Commercialization	-.064	.031	-.065	.043	*
Highest Involvement in Commercial Science	.009	.010	.027	.368	
1 Commercial Science activity *(Ref = None)*	-.102	.056	-.049	.071	
2 Commercial Science activities	-.088	.031	-.079	.005	**
3 Commercial Science activities	-.088	.026	-.096	.001	**
4-plus Commercial Science activities	-.036	.021	-.062	.077	
INSTITUTIONAL CS ENVIRONMENT					
Pressure Select topics with commercial potential	-.093	.032	-.110	.004	**
Pressure: Focus on applied outcomes	-.133	.022	-.190	.000	***
Pressure: Commercialize research results	-.097	.035	-.102	.005	**
Pressure: Limit publication of results	.011	.043	.007	.806	
Pressure: Generate revenues from my research	-.061	.019	-.084	.002	**
My academic institution:					
Has entrepreneurial environment	.002	.022	.003	.928	
Requires salary offset w external research funds	-.040	.013	-.080	.003	**
Provides financial support for my research	.036	.017	.055	.035	*
Has policies to restrict publication of research results	-.025	.025	-.026	.302	
Has procedural support for licensing/ patents	.010	.031	.010	.740	
Has policies to resolve conflicts of interest	.035	.028	.035	.215	
Rewards commercial science activity in P & T decisions	-.023	.022	-.027	.303	
SOURCE OF SUPPORT					
Current sponsorship: Government-Public agencies	.001	.001	.049	.168	
Current sponsorship: Industry-Corporations	-.003	.001	-.069	.015	*
Current sponsorship: Foundations	.001	.001	.031	.249	
Current sponsorship: University	.002	.001	.074	.021	*
Current sponsorship: Other	.003	.001	.062	.016	*
FACULTY TYPE PREFERENCES					
Old School	-.033	.040	-.024	.410	
Engaged Traditionalist	-.065	.047	-.040	.163	
Reluctant Entrepreneur	-.090	.043	-.055	.036	*
New School	.015	.042	.011	.719	
ACADEMIC DISCIPLINE (Ref = Social Science)					
Engineering	-.335	.076	-.145	.000	***
Medical/ Health Sciences	.044	.031	.047	.154	
Physical Sciences	-.011	.022	-.015	.631	
Biological Sciences	-.002	.016	-.004	.891	
INSTITUTIONAL TYPE (Ref = Very High Research Activity)					
Type-High research activity	-.022	.044	-.013	.618	
Type – Doctoral/Research Univ	-.005	.030	-.005	.854	
Control *(Ref = Public)*	.192	.054	.097	.000	***

	B	SEB	Beta	Sig.
Research Expenditures (Pctg.)				
Federal Government	-.006	.004	-.124	.088
State Government	-.005	.004	-.048	.266
Industry	-.007	.005	-.054	.134
Institutional Funds	-.005	.004	-.076	.224
(constant)	5.449	.442		.000
R^2	0.359			
Adjusted R^2	0.334			
Standard Error	0.643			
F	14.465			.000

Note: (N = 1,210; * p < .05, ** p < .01, *** p < .001)

Other significant predictors involve financial support, with industry funding having a small negative association, suggesting that faculty so funded recognize some restrictions on their freedom. However, receiving university research support and other funding each had positive associations. Turning to faculty type, only the preference for Reluctant Entrepreneur emerges here as a significant predictor, having a negative association with control. The negative effect makes intuitive sense given the thinking of this type that commercial science forces faculty to protect their work from industry.

Regarding academic discipline, being an engineer, relative to a social scientist, also decreases predicted control by - 0.36. However, it is unclear whether engineers use the same conception of control that social scientists would use. Finally, being at a private institution increases perceived self-direction over being from a public university.

These findings suggest that institutional pressures and internal policies that push or incentivize commercial science activity can affect how much self-direction faculty feel they possess when selecting research projects. Policies that exert heavy pressure on faculty can lead to decreases in self-direction, while those that act as incentives can be mixed. Having to attract funds to generate a salary appears to have a negative effect,

while having the university offer financial support for one's research program can increase the perception of control in this sense.

Also, situational contexts can have an effect, at least in terms of engineers, with this data indicating that they perceive less self-direction than their colleagues. This could be attributable to the nature of their work, which requires closer work with industry and private vendors, with greater focus on applied outcomes in line with those interests. In addition, increased knowledge of and participation in commercial science also leads to lower perceived self-direction, perhaps for similar reasons.

The model performs the best predicting this DV, Self-Directed Research; better than it did for any other variable in the entire study (adjusted-R^2 = .33). Since the study was conceived and the survey was designed with the goal of explaining this outcome, and the outcome variable consists of a unidimensional scale measuring control, it is a reasonable outcome for the model to have had the most success predicting this dependent variable.

The second regression is for the dependent variable called *Ability to secure funding*, the first measure from the original control scale (see Table 31, p. 177). Table 38 below (p. 188) displays the results of this regression model ($F=6.58$, $p < .001$) which accounts for more than 20% of the variance in the dependent variable. Again, the personal and career variables fail to emerge as significant predictors, indicating that perceptions of control over one's research are not attributable to these types of measures. However, experience does not emerge as a factor in any capacity. Unlike the model for the dependent variable for self-directed research, the variables related to

involvement in commercial science activities were not significant in this model. Neither 'knowledge of commercial science processes' nor 'involvement in commercial science activities' had associations as theorized.

Table 38: Regression Model Predicting Ability to Secure Funding

	B	SEB	Beta	Sig.	
DEMOGRAPHICS					
Gender	.033	.048	.022	.489	
CAREER					
8-15 Years in academia *(Ref = 0 -7)*	-.041	.057	-.024	.474	
16-24 Years in academia	.022	.061	.012	.719	
25-plus Years in academia	.000	.065	.000	.994	
Less than 1 Yr worked in Industry *(Ref= None)*	-.039	.079	-.014	.620	
1 to 5 Yrs worked in industry	.103	.057	.052	.071	
6-plus Yrs worked in industry	-.083	.065	-.039	.205	
COMMERCIAL SCIENCE INVOLVEMENT					
Knowledge of Commercialization	.040	.034	.042	.235	
Highest Involvement in Commercial Science	-.007	.011	-.020	.545	
1 Commercial Science activity *(Ref = None)*	-.079	.061	-.039	.194	
2 Commercial Science activities	-.045	.034	-.042	.178	
3 Commercial Science activities	-.008	.028	-.009	.762	
4-plus Commercial Science activities	.009	.022	.017	.670	
INSTITUTIONAL CS ENVIRONMENT					
Pressure Select topics with commercial potential	-.030	.034	-.037	.385	
Pressure: Focus on applied outcomes	-.002	.024	-.004	.919	
Pressure: Commercialize research results	-.109	.038	-.119	.004	**
Pressure: Limit publication of results	-.019	.047	-.012	.685	
Pressure: Generate revenues from my research	-.042	.021	-.061	.044	*
My academic institution:					
Has entrepreneurial environment	.017	.023	.023	.469	
Requires salary offset w external research funds	.034	.014	.070	.018	*
Provides financial support for my research	.111	.018	.175	.000	***
Has policies to restrict publication of research results	.004	.027	.004	.886	
Has procedural support for licensing/ patents	-.008	.034	-.008	.811	
Has policies to resolve conflicts of interest	.061	.030	.063	.045	*
Rewards commercial science activity in P & T decisions	-.039	.024	-.048	.104	
SOURCE OF SUPPORT					
Current sponsorship: Government-Public agencies	.005	.001	.248	.000	***
Current sponsorship: Industry-Corporations	.000	.002	.007	.827	
Current sponsorship: Foundations	.001	.001	.032	.281	
Current sponsorship: University	-.001	.001	-.049	.172	
Current sponsorship: Other	-.004	.001	-.080	.005	**
FACULTY TYPE PREFERENCES					
Old School	.041	.043	.032	.338	
Engaged Traditionalist	.015	.051	.009	.770	
Reluctant Entrepreneur	.058	.046	.037	.207	
New School	.093	.045	.069	.039	*
ACADEMIC DISCIPLINE (Ref = Social Science)					
Engineering	.024	.083	.011	.769	
Medical/ Health Sciences	.084	.033	.093	.012	*
Physical Sciences	.044	.024	.066	.066	
Biological Sciences	.066	.017	.137	.000	***

	B	SEB	Beta	Sig.	
INSTITUTIONAL TYPE (Ref = Very High Research Activity)					
Type-High research activity	-.041	.048	-.024	.393	
Type – Doctoral/Research Univ	-.010	.032	-.009	.764	
Control *(Ref = Public)*	.118	.059	.061	.045	*
Research Expenditures (Pctg.)					
Federal Government	-.002	.004	-.046	.571	
State Government	.000	.005	-.003	.948	
Industry	.000	.005	.001	.989	
Institutional Funds	-.002	.004	-.028	.685	
(constant)	2.219	.480		.000	
R^2	0.203				
Adjusted R^2	0.172				
Standard Error	0.697				
F	6.577			.000	

Note: (N = 1,210; * p < .05, ** p < .01, *** p < .001)

Regarding the institutional constraints, the pressure to commercialize results had a significant negative relationship with ability to find funding, as did having policies that link commercial science research to P & T decisions. However, three institutional commercial science policies did have positive associations. A requirement for salary offset (which had been negative for the self-directed DV), receiving university research support, and having policies for resolving conflicts were positively associated.

Having government funding as a source of research support was positively associated with ability to raise sponsored funds, although other funding sources were negative. Only one faculty type—New School—emerged as a significant positive predictor of ability to fund one's research. It is possible that these faculty view raising sponsored funds as part of their normal work duties, as the typology theory would suggest. For the academic disciplines, medicine and biological sciences have positive associations, relative to social science.

The environment for commercial science at one's institution is important for this model. Even policies that might be restrictive in other contexts, such as requiring a

salary offset, can have positive effects provided they are coupled with other policies that make faculty feel supported in their for commercial science activities. Being in a discipline that deals with commercial science regularly also helps, as does having a disposition towards New School values and beliefs about academic science.

The third regression model is also for a single variable from the original control scale. This variable is *Concern about conducting objective science*, and asked faculty whether they were worried their commercial activity could compromise their objectivity (1=Always, 5=Never). This model ($F= 6.307$ $p< .001$) accounts for almost 20% of the variance for this dependent variable (see Table 39, p. 191).

Some of the results for this model are similar to the first two, with background and career predictors failing to emerge as significant. However, similar to the first model and unlike the second, moderate involvement in commercial science activity has a slightly negative effect. Those results would indicate some concern about objectivity from having participated in such activities, although 'commercial science knowledge' was non-significant.

Other important predictors that were found to have significant negative associations include institutional constraints that cause faculty to feel pressure to select commercial topics, commercialize their results, and limit publication of findings from sponsored research. These associations suggest faculty are concerned such policies may compromise their ability to be objective. Meanwhile, receiving university research funding is again positive, and self-reported sources of research sponsorship had no significant effects.

Table 39: Regression Model Predicting Concern for Objective Academic Science

	B	SEB	Beta	Sig.	
DEMOGRAPHICS					
Gender	.022	.056	.012	.692	
CAREER					
8-15 Years in academia *(Ref = 0 -7)*	-.007	.066	-.003	.922	
16-24 Years in academia	.009	.070	.005	.896	
25-plus Years in academia	.015	.075	.007	.838	
Less than 1 Yr worked in Industry *(Ref= None)*	.143	.091	.045	.117	
1 to 5 Yrs worked in industry	-.107	.066	-.047	.105	
6-plus Yrs worked in industry	-.054	.076	-.022	.476	
COMMERCIAL SCIENCE INVOLVEMENT					
Knowledge of Commercialization	-.029	.039	-.026	.469	
Highest Involvement in Commercial Science	-.016	.013	-.041	.229	
1 Commercial Science activity *(Ref = None)*	-.161	.070	-.069	.022	*
2 Commercial Science activities	-.072	.039	-.058	.063	
3 Commercial Science activities	-.091	.032	-.088	.005	**
4-plus Commercial Science activities	-.042	.026	-.065	.102	
INSTITUTIONAL CS ENVIRONMENT					
Pressure Select topics with commercial potential	-.087	.040	-.092	.030	*
Pressure: Focus on applied outcomes	.019	.027	.024	.486	
Pressure: Commercialize research results	-.192	.043	-.181	.000	***
Pressure: Limit publication of results	-.122	.054	-.068	.025	*
Pressure: Generate revenues from my research	-.008	.024	-.010	.733	
My academic institution:					
Has entrepreneurial environment	-.028	.027	-.034	.300	
Requires salary offset w external research funds	-.002	.017	-.004	.892	
Provides financial support for my research	.075	.021	.103	.000	***
Has policies to restrict publication of research results	-.026	.031	-.024	.395	
Has procedural support for licensing/ patents	.048	.039	.041	.219	
Has policies to resolve conflicts of interest	-.042	.035	-.038	.231	
Rewards commercial science activity in P & T decisions	-.032	.028	-.034	.249	
SOURCE OF SUPPORT					
Current sponsorship: Government-Public agencies	.001	.001	.047	.236	
Current sponsorship: Industry-Corporations	.002	.002	.043	.179	
Current sponsorship: Foundations	.001	.001	.023	.452	
Current sponsorship: University	.000	.001	-.014	.703	
Current sponsorship: Other	.000	.002	.005	.866	
FACULTY TYPE PREFERENCES					
Old School	-.261	.050	-.173	.000	***
Engaged Traditionalist	.067	.058	.037	.253	
Reluctant Entrepreneur	-.020	.053	-.011	.702	
New School	.030	.052	.019	.566	
ACADEMIC DISCIPLINE (Ref = Social Science)					
Engineering	-.107	.096	-.041	.265	
Medical/ Health Sciences	-.002	.039	-.002	.957	
Physical Sciences	-.006	.028	-.008	.831	
Biological Sciences	.014	.020	.025	.487	
INSTITUTIONAL TYPE (Ref = Very High Research Activity)					
Type-High research activity	-.091	.056	-.047	.101	
Type – Doctoral/Research Univ	.006	.037	.005	.869	
Control *(Ref = Public)*	-.019	.068	-.008	.784	
Research Expenditures (Pctg.)					
Federal Government	-.003	.005	-.059	.466	
State Government	-.004	.005	-.033	.489	
Industry	-.001	.006	-.010	.800	
Institutional Funds	-.005	.005	-.077	.276	

	B	SEB	Beta	Sig.
(constant)	6.084	.554		.000
R^2	0.196			
Adjusted R^2	0.165			
Standard Error	0.805			
F	6.307			.000

Note: (N = 1,210; * p < .05, ** p < .01, *** p < .001)

The Old School faculty type has a significant negative association, indicating that, as expected, those who hold the values associated with conventional academic science would express concern about the intrusion of commercial science activity into their research. Academic discipline failed to emerge as significant in this model, again relative to social science. This was surprising, as the disciplines differ in regards to the levels of basic and commercial research they conduct. Finally, none of the institutional-level variables emerged as significant predictors.

With low values for the adjusted R^2, the second and third models, the only conclusion to be reached is that the models have too many predictors that do not contribute meaningfully to the explanation of variance in the population. The outcome variables for these two models were each part of the original 12-item scale for control, but were not part of the one-factor solution. Thus, they are measuring a different dimension than what they survey was originally designed for, and as such, the models suffer from poorer estimation.

Summary

Regarding the models for the primary dependent variable in the study, for the factor of self-directed research, most of the significant predictors had a negative effect on the perceived level of control. Measures of commercial science involvement like

'personal knowledge of commercialization processes', and 'participation in commercial science activities' were negatively associated with control, as were most of the institutional policies regarding the commercial science environment, especially those acting to increase the pressure for commercial outcomes. The only policy that increases control is 'receiving institutional financial research support.' This result is reinforced by the outcome that 'university funds as a source of support' increases control. Industry support was negative. Only one type, Reluctant Entrepreneur, was significant with a negative association, and engineering emerged as the only discipline to have an effect relative to social science, and this effect was also negative. A final positive association comes from being a faculty member at a private institution.

The second model was for a single variable, and this was an item that read: "I am able to find funding for the questions I wish to pursue," which was coded so that 1=Never, 5=Always. Most of the significant predictors had a positive association with this dependent variable. While two institutional policies that increase pressure for commercial outcomes and getting research funding from other sources were negative, policies to offset salary with external funds, resolve conflicts, and provide institutional research support were positive. Higher levels of government research support, being New School, being in the medical or biological sciences, and being at a private institution were associated with increased ability to secure funding.

The third model was also predicting a variable from a single question: "I am concerned that my commercial activity will compromise my ability to conduct objective science." The variable was measured as a frequency of occurrence with vague

quantifiers; 1=Always, and 5=Never. This model had fewer significant predictors than the others. More commercial science activities, policies that increase pressure for commercial outcomes, and being Old School were negatively associated with this concern about maintaining objectivity. The only positive predictor was receiving institutional funds to support research.

CHAPTER V. DISCUSSION AND CONCLUSIONS

This chapter begins by providing context for and a consideration of the two primary components of this study—the faculty typology and the analysis of the concept of control over research agendas. The discussion of the faculty typology builds from research questions 2, 3, and to some extent 4. The reflection on the dependent variables for 'control' uses data analyzed for research questions 1, 4, and 5.

The implications section considers the consequences of these results, both for the theoretical underpinnings of the study and the effects these findings could have on outcomes related to policy and practice. The chapter concludes by outlining limitations of this particular study and by offering suggestions for future research that follow directly from this study, as well as some that diverge.

Discussion

A distinction exists within the field of science studies between scholarship concerned with fundamental and theoretical understanding of the development of scientific knowledge, and the scholarship focused on the critique of science and technology as social institutions and their effects on society. This has been called the 'High Church—Low Church' divide (Fuller, 2004). The theoretical literature (High Church) is concerned with the internal dynamics of the processes and resources used to construct scientific and technical knowledge, while the more critical component (Low

Church) examines the political and practical value of science and focuses on policy, reform, the governance of science, and activism for the public interest (Sismondo, 2008).

The two primary components of this study have touched on both sides of this divide. The examination of the faculty typology and the consideration of its types as proxies for different institutional forms and value systems in academic science is a 'high church' issue because this strand of science studies has focused on the effects of social factors on matters like topic choice and what counts a good science (Hess, 1997). With its consideration of the processes of academic science as a socializing system that condition faculty to approach science with particular values, we gain some knowledge of how different normative systems can influence the construction of scientific research.

The focus on the ethos for science is important because Merton saw science as a self-regulating system governed by its norms (Bucchi, 2004), however the criticism of Merton is that such norms cannot fully explain the social behavior of scientists. Rather than approach the study of this institutional environment for science as the governing power of a particular set of norms, the typology component of the study was designed to determine whether alternate institutional forms that touch on this expanded notion of academic science would be seen as legitimate. Through the consideration of dimensions that acknowledge the social connection of academia to industry, and of an array of issues that constitute part of the substance of academic and commercial science, these alternate institutional forms provide insight into the reflexive and socially constructed nature of research (Knorr-Cetina, 1991).

The other component of the study—control over research agendas— comprises the 'low church' emphasis because of the focus on issues pertinent to the concern over the loss of autonomy and objectivity in academia. The apprehension in the higher education literature about collaboration with industry and the infusion of private capital into research is consistent with the concern in science studies about socially responsible science, increased democratic participation in governance, and the determination of science policies that will benefit the widest populations (Sismondo, 2008).

Scholarship within higher education in this category has generally focused on the perceived loss of "pure" science, such as corporate influence pushing out democratic values (Slaughter & Leslie, 1997) and the articulation of a research policy that outlines the roles of governments and universities in commercial science (Metcalfe, 2008), while broader disciplinary perspectives have examined how science is interconnected with the political economy and affected by regulatory and market externalities (Frickel & Moore, 2006).

The contention that involvement in commercialization will compromise universities is grounded in a contrast of the two distinct cultures present within academia and industry (Bok, 2003; Rosenstone, 2001; Washburn, 2005). Industrial and academic research have fundamentally different goals that involve the sharing and use of information, what counts as competitive advantage, and how success is judged (Bird & Allen, 1989; Geiger, 2004).

There is not an established location for the construct of 'faculty control over research agendas' as part of the research policy framework of mission, support,

management, and translation outlined by Metcalfe (2008), but as defined in this study, it would seem to span the areas of support (the funding subcomponent, in particular) and management, which focuses on institutional-level policies. Because the construct of control is part of the academic freedom of faculty and is viewed as tied to the overall autonomy of academic scientists, concern over its sustainability will be of interest to those seeking to reform academic science and maintain its independence.

The discussion will first focus on the faculty typology and the findings regarding normative systems in academic science. Those results will address the second and third research questions for the larger study. Then the discussion will shift to the outcome measures of control examined in the study, thereby addressing the first, fourth and fifth research questions.

Faculty Typology

The second research question in this study was seeking evidence that university faculty had beliefs about academic science which diverged from the traditional norms of Mertonian science. The premise was based on the established concepts in the literature that institutions like academic science can be modified over time as people adapt to conflicts and ambivalence about existing beliefs in light of external challenges. Using a typology as proxy for alternate institutional forms, the study also sought to determine whether faculty respondents could be classified into one of these types using value statements developed for each type. Preference for non-conventional types could be evidence of the legitimacy of alternate value systems. Additionally, the third research question concerned the background characteristics associated with each type.

Key Findings

Mertonian science persists as an ideal; Old School is prominent, but not dominant

The literature examining Mertonian norms and the analysis of this data each point to deviations from the values conventionally associated with academic science by the higher education literature. However, the norms as an ideal for research practice still hold considerable sway, at least as a governing ideology. As a proxy for Merton's norms, the values represented by the Old School type retain a prominent place among the faculty studied here; it was the second-most preferred type in both classification methods discussed, with a weighted average of 28% (see Table 17, p. 143). Its proportion remained consistent across the two classification schemes, and it was the most frequent type among biological and physical science faculty.

Among the individual Old School issues, there were high levels of agreement for four of the five, although the basic/applied research separation registered the lowest score among all 20 statements (1.76). Perhaps this could be a clue as to why this value structure does not dominate those represented by the other types. The findings from earlier studies that the conventional position's status as an ideal does not translate to practice were again observed. Still, over 40% of the faculty had Old School as one of their top two preferences.

Support was found for alternate institutional forms, in particular the legitimacy of New School

Returning to the question posed earlier regarding alternate value systems and deviation from Mertonian science, three value systems for other potential institutional forms were considered in this study, and all three found support. The strongest evidence of legitimacy was found for the position opposite the traditional one—New School—which acts as a proxy for the transformed views of academic science resulting from perspectives such as Mode-2 science and the triple-helix model. It had the highest average across the two classification distributions –32%–and in the one using indices, it was the most preferred type.

New School also experienced the greatest consistency between the two schemes, as more than 56% of those initially classified as that type were present in the second distribution. But New School also experienced the biggest positive change in distribution of any of the types, as the losses among the other three types all accrued to the New School (see Table 18, p. 145). Thus, using the index classification, the largest proportion of faculty in this study do not view commercial science as a threat and see the overlap of the academy and industry as necessary for conducting quality academic science. The individual New School index items also found moderate to moderately high agreement broadly. Also, perhaps not surprisingly, the disciplines with the highest percentages of New School types are engineering and medicine, although all disciplines have proportions greater than 30% of their faculty preferring this type.

Engaged Traditionalist emerges as the stronger hybrid position

The value systems approximated in the hybrid types also received some support, with the Engaged Traditionalist position easily being the stronger of the two, with an average of 31%. This type also does not perceive the academy as threatened by commercialism, even though faculty with this belief system view the academy as distinct from industry. They negotiate the challenges by maintaining the separation between the two realms, and believe individual faculty can conduct research in both realms without compromising the academy as a whole. Having this type emerge so prominently could mean either that the commitment to conventional norms for research remains quite strong, or that the traditional values themselves are quite resilient and are not necessarily undone or quashed by engagement with commercial science.

Still, comparing the self-placement and index classification schemes, the Engaged Traditionalist type had a substantial loss of frequency relative to the distribution gains observed among the New School and Old School types. Based on the index preferences, Engaged Traditionalist has a pretty even distribution among the disciplines, ranging from about 17% to 23%, and Engineering has the highest percentage of this type among its ranks. The relative lack of preference for the Reluctant Entrepreneur position could either mean that these faculty are not in a position often enough to be forced to make some decision to protect their work from encroachment by industry, or that the type construct itself does not reflect a reality faced by a large proportion of research faculty.

Of course, the possibility exists that the subtleties of this position could be drawn out with more effectual scales that touch on the different nuances of this complex construct. Evidence certainly exists for differentiation in the way faculty approach commercial activity, as recalled by the distinction by Meyer (2003) between entrepreneurial academics and academic entrepreneurs.

Use of the typology as a classification scheme was not supported

Regarding their potential as a classification scheme, the faculty type constructs tested in this research exhibited mixed results here, so these results should be considered inconclusive at best, with a strong possibility that the typology is simply not workable as an effective framework for reliably differentiating among academics. For now, the basis of the Owen-Smith and Powell (2001) theory that academic scientists could be classified into one of four distinct types was not supported. The distribution of faculty did not produce the sort of clustering that would have to be expected from distinct types.

Only two of the 11 regression models for control had more than one faculty type variable emerge as significant predictors; in seven models, just one type was significant, and the effects were mixed overall. It was hoped that the type variables would be robust predictors that would play a role in making a distinction among faculty for outcomes such as control over research. As such, they could not be used as the major predictors that the design originally intended.

The typology could represent non-exclusive, context-dependent institutional forms that faculty can move between or use simultaneously

Despite this poor performance as a classification scheme, the typology may represent something very real as a spectrum of value systems upon which faculty can draw as circumstances warrant. The results from this study suggest that faculty ascribe to values associated with multiple types, and that they often prefer ones that represent positions that differ from the norms of Mertonian science. The conventional, Old School value system was still embraced by many faculty, but it is not the most preferred. The values and beliefs associated with its polar opposite—New School and its attendant embrace of the culture of industry sponsored research and applied outcomes—was actually the most preferred system, both alone and in combination with the other types. The embrace of multiple positions lends support to the theory outlines by Owen-Smith and Powell (2001), who based their creation of the hybrid types on the fact that their interview subjects "simultaneously partake of multiple logics to to justify their activities (p.5).

Such results would validate the assertions from earlier studies (e.g., Mitroff, 1974) which claimed there were opposing norms that offset Merton's, but were nonetheless needed to provide balance and ultimately support the advance of science. The science studies literature on the new context for science is seeking to get inside the "black-box "of Mertonian science, recognizing that science, as a social system, is a contested terrain just like many other cultural institutions (Kuhn, 1962). Merton's embrace of sociological ambivalence showed he understood how social factors can cause faculty to struggle and recognize the need to adapt the accepted norms for

practice to the external circumstances. Certainly Merton and others saw the need to reconcile the traditional ideology of science to its modern practice (Hess, 1997).

The expansion of big science as a complex enterprise involving multiple sectors of society has been called "post-academic" (Ziman, 1996). Certainly, the transformation of academic science has altered the processes for knowledge production. We may be seeing faculty operate with different, but no less legitimate, sets of values, and even move between them as needed. Given the increasingly porous boundaries between society, industry, and science, and because of the decreasing internal consistency of the shared values, norms, and practices of modern scientists, the term "scientific community" may no longer describe the academic scientists working inside research universities, (Bucchi, 2004).

Control Over Research

Key Findings

Control as complete autonomy over the direction of one's research or as "curiosity-based research" was NOT supported as the prevailing definition emerging from this study.

The first research question in this study asked about the extent to which faculty believe they must compromise control over their research. Given the moderate scores on the primary dependent variable and all four topic choice scenarios, faculty do not feel that sponsored university research is entirely self-directed; certainly the literature on the diversity of influences affecting academic science has cautioned us to expect as much (Anderson & Seashore-Louis, 1991). Control defined as "being able to obtain

funds based solely on my interests" in the Curiosity scenario scored lower than the Compromise and Concession scenarios: Curiosity's rating for government funding was just the 5th highest out of the eight scenarios, and its rating for industry funding was the lowest score overall. Other outcome variables, such as "I am able to find funding for the questions I wish to pursue" rated between Occasionally' and 'Usually', although it cannot be known from this data to what extent those scores are a function of limited funding availability in particular fields, as opposed to sponsors' attempts to direct or change the direction of projects.

The levels of control expressed by these faculty on the multi-item scale were moderate to moderately-high; all were above the mid-point (3.0) and a few approached and exceeded 4.0. The mean for the variables comprising the "Self-Directed Research" factor was 3.57. Regarding the control scenarios (Four Cs), while there were no levels of self-direction that could be considered very high, and few scores on the freedom from interference could be classified as such, the moderate scores across the board suggest that faculty control is not in danger of being run over by sponsors and subjugated to their whims. Ziman (1996) acknowledges that it is unlikely that 'post-academic science' will be given over completely to commissioned research, but he does worry about who will set the problems when researchers work in teams with those whose interests go beyond just producing knowledge.

The level of self-direction did not differ by faculty type.

Addressing the fourth research question in the study, the four faculty types showed no significant differences on the primary outcome variable in the study, 'Self-

Directed Research.' The ANOVA approached significance levels, but the results reinforce the other findings from this study that the type constructs themselves do not produce sufficient distinctions between faculty. Nor were the type preferences major contributors to the explanation of variance in the regression models. Old School was associated with greater concern for objectivity in academic science, while New School was positively associated with 'ability to secure funding.' Overall, it was a disappointment that the types could not be used to compare groups of faculty on the primary dependent variable.

Institutional policies and environments can support, constrain, or contextualize adaptations to transformations of academic science for faculty who are situated differently.

Different forms of institutional policies can contribute to or take away from the sense of self-direction in research that faculty perceive. Policies that make faculty feel too much pressure to produce commercial results were virtually always negatively associated with control in all the models tested here, while university financial support of research was significantly positively associated in 6 of the 11 models. In any case, it seems that the policies adopted by institutions can have an effect on making commercial science something faculty feel they either have to do or something they believe they can do, with proper support.

Where faculty conduct their research, in terms of their discipline and institution, seems to have some effect. Being at a private university was associated with higher control in the models for 'Self-Directed Research' and securing funding, but was not significant in any of the scenario models. Some disciplinary differences could be

attributable to how often faculty are willing or required to place themselves in situations where their control and academic values will be challenged. For instance, engineers report lower senses of control than social scientists, but could simply view such trade-offs as part of their work and thus, encounter it more frequently. Engineering was negatively associated with control in three of the four models where it was significant. Other research has confirmed that faculty participating in industry collaborations have different views on them than do non-involved faculty and that such faculty are more willing to tolerate ambiguity and negotiate potential conflicts of interest (Campbell, 1997; Campbell & Slaughter, 1999). For engineering, autonomy could be a luxury standing in the way of otherwise productive collaborations.

Other faculty may be in a better individual situation, such as having the experience of securing grants, or being in a field where that type of activity is not as prevalent. Social scientists have the highest scores for control in the group comparisons of the primary dependent variable, Self-Directed Research,' and the eight control scenarios, by discipline. Social science is significantly different from every other discipline in the self-directed research comparison, and from at least one other discipline in every one of the control scenarios.

Some findings from the regression analyses were surprising, particularly how certain items were non-significant. Years as an academic and years experience in industry was not significant in any of the three primary models. However, 'years as an academic' was associated with increased control in three government-funded scenarios of the 'Four Cs', providing another twist on the phenomenon in the reward structure for

science known as the Matthew effect in which those with the most success accrue even more (Merton, 1968). Industry experience was positively associated only for Collaboration. Although a plethora of research centers that collaborate with industry have made moving between academia and industry more commonplace (Dietz & Bozeman, 2005), the effect from working there on the determination of one's own research agenda seems to be modest.

Involvement in commercial science activities appears to have mixed effects. Increased involvement in or knowledge of commercial science appears to cause some faculty to feel more secure about their research, while causing others to become overcome by the ambiguity. This could also be because many people rated themselves as having limited knowledge, and perhaps they rely on institutional policies more.

Government funding support to individual faculty was rated as leading to a greater sense of control than did industry funding.

Receiving government or industry funding is associated with higher control for three of the four scenarios. However, in the group comparisons for self-directed research, there was no statistical difference between those receiving 0% and 100% of their research support from the government, although those getting 100% had a higher control score than those receiving 50% – 75%. Also, industry funding seems to have a negative effect. While these outcomes may be expected, they do present some unknowns regarding the construct of control. Perhaps there are different conceptions of control that should be defined when referring to each type of funding. Faculty receiving industry funding may express lower absolute rating for control, but is there a

single measuring stick? Do these faculty have the same expectations for control that faculty competing for government grants do? As a matter of frequency, faculty routinely obtaining this type of funding may have a different understanding of what it means to design a study according to one's interests. These observations lead to the last finding.

Control does not appear to be a steady-state. Rather than autonomy, control was more likely to mean the ability to overcome influences and interference from sponsors to obtain most of what was desired.

There may indeed be different levels of control regarding research, but it may also be possible that there is not one standard when it comes to control. It is not known whether everyone would define it the same way, and it stands to reason that not every academic scientist gets the same starting point, owing to personal, institutional, or disciplinary factors. Perhaps we need a more nuanced definition or a spectrum of control levels or types. One starting point may be provided by the control scenarios.

Since faculty in this study could not define their research agenda with absolute authority, it should be noted that a considerable aspect of academic freedom in research seems to be the ability to overcome interference from sponsors to obtain one's research interests. Based on the findings discussed here, the freedom from interference and sponsor hindrances could be what is most important to defining a realistic sense of control over research. All four of the outcomes involving negative scenarios had significantly higher control scores than did the self-direction items, regardless of funding type. Thus, having the ability to overcome sponsor interference or negotiate issues away seems to be a critical component in having control over research, more so than having autonomy.

Conclusions

As discussed in the introduction, the modifications to the practice of academic science are part of the broader transformations in society resulting from the political, economic, societal, and cultural dimensions of globalization. One of the most prominent tensions discussed in the literature on globalization is that between the forces of modernity on the one hand, and the cultural groundings people cling to during social upheaval—their identity—on the other. Higher education finds globalization so unnerving for the same reasons citizens around the world do; it produces a tension between the modernity of the global knowledge economy and what institutions consider their identity—the deeply-held beliefs regarding the idea, purpose, or mission of a university. This is particularly unsettling for institutions accustomed to tradition, autonomy, and a certain degree of deference from society on intellectual matters.

The paradox of globalization is that as the world becomes more interconnected, local communities, institutions, and processes become more important (Giddens, 1990, 2000). One problem is that the history of globalization has shown that the economic and political changes occur ahead of the cultural and broader societal ones. The same occurs at the university level. Disciplinary inequities become manifest as some are able to embrace the market more easily than others. And as Clark's (1998) institutional case studies reveal, the initiatives to secure external funding move ahead before the institution becomes fully culturally engaged in entrepreneurship. It is this cultural lag that causes consternation among citizens and scholars alike. This tension must be addressed and managed for institutions to adapt.

Is academic science a social institution? Certainly the sociological literature on science and the production of knowledge believes this to be the case, and the growing literature on institutions in education recognizes university research as one. The types considered in this study were not institutions, but the values they present are reasonable embodiments of new institutional logics as created by faculty having to adapt to the ill-structured nature of being caught in a transformed environment for research. We probably do not know the new form academic science will take, but the confluence of forces discussed and studied here would seem to indicate that it will contain some of the reflexive properties of other social institutions. These include an integration of personal values, university cultures, disciplinary influences, and government demands with the global trends of innovation networks, dispersed influence, and stakeholder involvement.

Global demands are always filtered through local norms and values; they can be filtered out, or integrated. Adaptation is a process of bricolage—borrowing and copying ideas from elsewhere, drawing upon local knowledge, trial and error, until something new that works is created (Ball, 1998). Two concepts come together to support the notion of faculty adapting to global trends in their local contexts: the concept of reflexivity that was introduced in the original discussion of globalization, and the concept of institutional adaptation through the 'choices-within-constraints' process by individual actors with agency.

If faculty do in fact feel Merton's sociological ambivalence about their individual roles as researchers part of the larger academy, these theories point towards a way of

identifying the processes by which any such change could be studied. Waters (2001) stresses that there is a 'localization' aspect to the globalizing, in which local actors will increasingly seek to self-author their communities but will make these decisions using global referents. The reflexivity thesis is that the knowledge economy/information society is generally empowering because it allows people to access more knowledge to shape their lives (Delanty, 2003).

An integrated model of knowledge production must incorporate several elements to show the cycle of connections amongst actors. First, universities will have to acknowledge some acceptance of the concept of socially distributed knowledge; universities are no longer the only source of knowledge creation, and more aspects of society have demands for knowledge that has uses for problem solving and practical applications. Second, universities (and their faculty) should view themselves as situated within some form of a knowledge region or network in which universities forge relationships with governments, industry, and other seekers and users of knowledge.

Whether this perspective on the university takes the form of Mitra and Formica's (1997) "social context of innovation" or Walshok's (1995) "Technopolis" is a matter for design and debate, but it will most likely be a network university (Dill & Sporn, 1995a) in which the connections are present at multiple levels—across departments and disciplines, as well as administration and faculty. Policies, research, and strategies will have to be crafted with a sense of the complexity and contradictions inherent in the globalizing world. For universities in the marketplace, this means not entering the

market by attracting just a few financiers, but to engage with enough so that no one single provider dominates research agendas.

Another important question is whether universities can be agents for social transformation in the global knowledge environment. The concern in both the higher education and science studies literatures over potential restrictions of freedom and the compromise of basic research for faculty resulting from sponsored research is not without merit. But we should keep in mind the single-digit percentages of total university research expenditures that come from industry, as well as the enormous investment in research and universities in general that give multiple publics a stake in what happens. A knowledge region means that many types of organizations are in partnership with institutions, or are part of the information flow, and it is now a reasonable expectation that these external actors will want to verify that the universities are performing adequately (Power, 1997).

Surely, a university engaged with these publics can have more influence than one subsidized by government funds alone. Neave (2000) observes that the Humboldtian tradition of a university separated from society via the barrier of state support to ensure that the university was a disinterested site of learning and scholarship, unrestrained by external agents, may no longer be feasible. However, he offers this counsel to higher education:

> It is no longer sufficient to be *in* the world. The university has also to be *of* the world. Thus, the responsibilities of the university…seem to be expressed not in its detachment from society so much as in its close, if not symbiotic, engagement. There is much to be gained by the lowering of academia's draw bridge. But, such a gesture is not without its consequences. One of these must

> surely be that each and every university is now faced with the full weight of responsibility for the actions it undertakes…Such entrepreneurship in no way absolves universities from the moral, ethical and social consequences which arise from such undertakings. On the contrary, entrepreneurship merely underlines them (p. 24).

Both the field and the industry of higher education will have to embrace a future of university engagement with civil society in terms of the research enterprise. Any advocacy for funding via government provisions to the exclusion of all other means seems unrealistic, and poorly serves universities that should be positioning themselves as global knowledge producers. The history of science has shown that governments of either ideological persuasion can attempt to direct the products of academic science toward ends that comport with their visions (S. Turner, 2008). Keep in mind that a resistance to government authority over science is what prompted Merton to develop his normative structure in the first place. However, as this study has shown, those norms no longer provide a sufficient guide for academic science.

This study, along with its review of the literature concerned with the normative structure of science, should serve as notice to the higher education community that academic science and its participant universities would be better equipped to meet the challenge of the global economy as knowledge producers if they were not constrained by norms for science that were developed in 1942. The institutional logics presented by the Owen-Smith and Powell typology are reasonable starting points for a new social structure for science. Even if the type constructs themselves are not discrete, the values on which they are based are grounded in the transformed research environment. Thus,

we should view Mertonian science the way the sociologists of science do: as a contribution valuable in its time, and of its time.

That support was found for the alternate value systems speaks to the broad nature of the changes in academic science. The design of this study included drawing of faculty from disciplines other than just the high-tech fields because the theories addressing the transformation—especially Mode-2 science—indicate that the changes are occurring across the entire academy. The finding that New School found support across all disciplines was meaningful because it provided some evidence that Gibbons, et al may be correct about the widespread nature of the modifications to traditional academic values. To further test this hypothesis, studies of control and values should be conducted among faculty in even more disparate fields, as Mode-2 theory states that the transformation of knowledge production includes even the humanities.

Still, we should ask if another criterion is needed besides values to gauge the extent to which academic science is being changed. Values and the normative structure are the context of science—we need to know more about the content of science. Context is conceptualized as having a direction of causality going from values to practice: the context (values) influences the practice. We should also determine the extent to which causality may run in the opposite direction, with the content and practice of science influencing the values and context. These results show that how faculty are positioned in their field or across the university can affect the way they approach an important aspect of their work, such as expectations for control over their research topics. There is a good chance that other variables, like location in a particular

state/region, involvement with specific networks and collaborators, or certain types of funding sources could have even more influence over how control is perceived.

Just as regional positioning could be important, so could location in different national university systems. Securing funding in the US differs from the process in other countries, and it would be interesting to determine whether the level of control over research increases or decreases when the competition is among faculty at one's own institution. Also, the position of other governments on how they should engage with universities for economic outcomes would be an important factor, such as the move toward the steering and evaluative state in Western Europe. For example, one might find that the long-standing commitment to Social Democratic principles has led to an expectation from faculty that government should provide money with little oversight, but this will be changing as governments adopt more forms of accountability.

The study of entrepreneurial institutions not only needs new conceptions but also new tools for inquiry. A possible framework comes from an examination of universities in the Italian system. Lazzeroni & Piccaluga (2003) say that traditional methods of evaluation and old indicators of performance are not applicable to institutions that are engaged with industry and economic development. They offer four conceptions of the university in which it can function as a factory for: 1) knowledge, 2) human capital, 3) technology transfer, or 4) territorial development. Faculty that identified with these four positions would no doubt have very different expectations for academic science at their university, and would probably view basic science, research collaborations, and sponsored research through their experiences accordingly.

Finally, just as the primary type constructs in the typology theory were not dichotomous and required the extension into hybrid types, so too, control should not be viewed as a unidimensional construct. The factor tested here was called self-directed research, but it was surprising that the first item on the original scale –"*I am able to find funding for the questions I wish to pursue*"—decreased the reliability of the factor scale. This suggests that, perhaps, finding funding and being self-directed are not as inextricably linked as is commonly asserted in the higher education literature. With the idea of control not having a universal meaning, it would appear the relationship between being funded and having self-direction requires greater clarification.

Implications for Policy and Practice

Both components of this study are concerned with the autonomy of science, sharing a focus on the independence of individual faculty from the demands of external actors that obtain entry into the scientific process, either as a sponsor, collaborator, or both. The recent decades have witnessed a move from concern over state and military intervention to private capital and industry partnerships. The higher education literature has contended that the preservation of independence for faculty is best achieved through the separation of academic and commercial science because their values are so divergent. The results from this study suggest that faculty have a strong tolerance for the ambiguity that results from the overlap of academic and commercial science, and that they can negotiate and adapt to this situation by demonstrating facility with multiple normative structures and employing them as the contexts warrant.

These results also show that the traditional norms of academic science are not necessarily abandoned by the invocation of alternate value systems. The high preference for the New School type in the index preference distribution suggests that rather than disillusionment or corruption, the viewpoint that the academy and commercial science overlap and that higher education is not threatened by commercial science represents a realistic, healthy engagement with a transformed environment that not only views universities as contributing to economic growth, but also recognizes their potential prominence of place within a distributed system of knowledge production. Furthermore, the embrace of the Engaged Traditionalist position of individual faculty keeping academic and commercial science separate suggests that these respondents believe that faculty can locate their boundaries and maintain a balance between the two realms without the need for extensive regulation.

Of course, the climate for entrepreneurialism and the support for commercial science activity that exists within a department or institution are important. The literature and this study both show that being involved in commercial science activities and having the opportunity to increase one's knowledge of commercialization processes can enhance the perception of control. Supportive policies and the opportunity to get involved can demystify the commercial realm while also removing the stigma of association with such work.

The faculty in this study may not have defined their level of control as complete autonomy, but neither have they expressed a sense of being subservient to the demands of their research sponsors. Control was moderate to moderately high in many

cases. The fact that disciplines closer to industry or more involved with commercial science expressed lower control could either mean that those faculty perceive some loss of self-directedness, or it could be that they have a realistic conception of what being self-directed means in a transformed research environment.

There are also considerations for academic science at the individual, institutional, and collective levels. Faculty may direct their own research programs and make use of the networks and skills they have, but they also work in disciplines that differ with respect to the types of research that can attract external finance and collaboration, and they conduct research at institutions that have policies and infrastructures that vary in levels of support and pressure for commercial science. All of this culminates in an effect across higher education with consequences for the role of universities as producers of knowledge and knowledge products.

For some departments and some faculty, personal career characteristics or policies that enable individual faculty to maintain their own balance may be sufficient; however it is likely that most faculty will require more structure from their institutions, especially given that overcoming interference from sponsors was more important for control than concepts like autonomy. Leadership and policy structures that enable faculty to approach sponsor demands as part of the research design process, and the sponsors themselves as partners rather than as simply funding providers, seem like reasonable expectations for helping faculty engage and adapt with this environment.

Administrators and policymakers should realize that even an abstraction like the social relations of knowledge production can have real and very practical consequences

for the types of research that universities produce. Where opportunities exist to create innovation networks, research parks and small business development centers, inter-university consortia and other collaboration formats, they should be embraced because they increase the engagement of their faculty with the transformed environment for academic science.

Implications for Theory and Research

The results from this study indicate that a more complicated definition of control is in order, since it appears not all faculty may have the same expectation or opportunity to exercise a given level of self-direction. As was noted in the discussion, the control scenarios used in this study could provide one method for developing an expanded definition of control. Because overcoming sponsor influence proved to be a more meaningful component of control than did autonomy, and because those disciplines closer to commercial science may face greater challenges from sponsors—but also better opportunities to secure funding—it is possible that a spectrum of control would be more realistic. Such a spectrum should have some allowance for overlap between control outcomes, as individual faculty will not have equal opportunities to secure funding, or be equally adept at overcoming sponsor influence.

Figure 6 below, which allows for movement along both axes to locate individuals along outcomes that have some range, could more accurately represent the possibilities faced by faculty. The horizontal axis represents a spectrum from having sponsors influence research agendas to having their wishes incorporated into the goals of the researcher. Also, the vertical axis is “likelihood” for securing funding, as opposed to

'skill' or 'ability' to secure funding, since not all disciplines or institutions present faculty with equal opportunities for grants and other resources. The outcomes are theoretical positions, as faculty may be higher or lower along the axes for any particular outcome. Having ranges that overlap signifies that faculty could move through one outcome to get to another, or occupy some middle ground as research collaborations proceed through various stages, from design to research to dissemination.

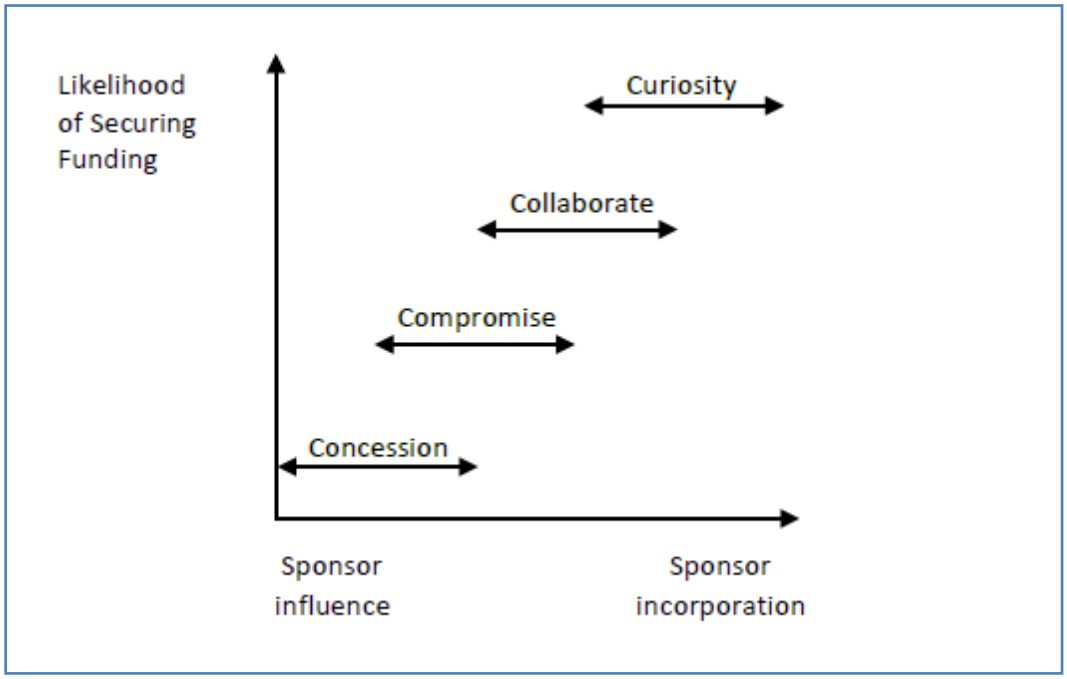

Figure 6: Possible Outcomes for a More Complex Representation of 'Control'

Could the framework of the faculty typology provide insight into how individual faculty can find such a balance? First is the question of whether the types even exist. The failure to establish the types as stable, reliable, and distinct has been discussed, and it is possible that the constructs as defined by the original theory are not generalizable or applicable to diverse groupings of faculty, such as those sampled for this study.

Recall that they were developed for the life sciences; it could be that other disciplines would have different type constructs. However, given the varied preferences expressed by the faculty, it does seem reasonable for some framework of multiple value systems to exist. Their level of definition and permanence remain to be determined, but their existence as institutional logics seems probable.

These differing value systems, perhaps represented by the type constructs used here, provide evidence that faculty are—to use a sociological lens—reflexively adapting to the transformed research environment (Bauchspies, Croissant, & Restivo, 2006). While faculty predisposed to conventional (Old School) perspectives on academic science may disapprove of the invention of new norms or scientific practices, such practices could represent an acceptance within the scientific community of the new research environment, and adaptation to it. Etzkowitz (1989) describes this as the occurrence of normative change, rather than the stigmatization of deviance.

Evidence of support for alternate value systems regarding what constitutes good academic science could be similar to the way scientific thinking often works regarding any phenomena of interest. Conceiving of science as a social activity, Hess (1997)—taking a cue no doubt from Kuhn (1962)—points out how the three phases of research involve scientific revolutions, controversies, and normal science. The current environment for science has been defined as a revolution (Etzkowitz & Webster, 1998), and we are certainly in the midst of controversy regarding what academic science should be, so it may be some time before the final verdict is in on what constitutes the new normal science.

With this in mind, the two components of this study can be joined because the transformed research environment has implications for both 'control' and accepted scientific practices. It may be unrealistic to expect to find completely disinterested academic scientists, as all academics have problems that interest them, and the idea of a lone truth-seeker working with complete neutrality and autonomy in the era of big, complex science seems unworkable (Bucchi, 2004; Ziman, 1996).

There has always been a tension between the universalistic values of science and the particularistic values of faculty (Hess, 1997), and academic science would seemingly be better served by acknowledging the positive aspects of these beliefs that motivate faculty to drive research into areas that satisfy their curiosity. "Standpoint epistemologies" (Harding, 1992) like feminist theory violate the norm of universalism, but that does not disqualify their advocates from the production of objective science. Perhaps science and technology studies (Hackett, Amsterdamska, Lynch, & Wajcman, 2008) can ascertain whether and how the institutional logics that govern the organization of scientific practice can keep pace with the factors that determine the conduct of scientific research.

Limitations of the Study

The measurement of control over topic choice could be performed with more complicated constructs than the ones employed here. The schematic presented in Figure 6 could be a starting point for more context-specific theories and definitions. Future research should try to isolate the effects of particular disciplines, institutions, and sponsor relations. A focus on funding type is promising, as there are clear differences in

restrictions for faculty dealing with government agencies and for those working with corporations. In addition, control could be examined at different points in time of a research project, so as to determine how much control faculty have over what topics to explore, the final topic choice, and what aspects of the research design and methods are subject to negotiation and agreement.

The failure of the typology as a classification scheme could be due to its type constructs, or their applicability as outcomes to be predicted, while the possibility of measurement error in the design of the scales also certainly exists. These results would seem to validate the assertions from the science studies literature on the new context for science and how this affects its content. It may not be reasonable to expect faculty to reliably differentiate between constructs that could be context-dependent or based on subjective criteria like the perception of threats, which in turn could be affected by the different disciplinary, departmental, or institutional circumstances of individual faculty. Also, it may not be appropriate to incorporate norms and values into the same instrument, as they could measure different things, such as regulations and principles, respectively. In addition, the directionality of cause and effect between one's issue positions and beliefs on particular issues concerning academic and commercial science was not explored in this study.

The study may also have produced more robust findings if the faculty sample had been more involved with commercial science. These respondents had some involvement and experience with such activities, but most did not. This was part of the original conception for the design. As the theories on the transformation of academic

science suggest that the changes occur across the academy, faculty from multiple disciplines were targeted, but involvement in commercial science was not a requirement for inclusion. Perhaps a more focused sample of faculty in different disciplines that possess greater experience in commercial science activities would shed light on how the adaptation to this environment occurs.

Suggestions for Future Research

The concept of control over research agendas is an under-researched phenomenon in the higher education literature, but also in the broader social science and science-focused literatures. We should know more about the relationships between sponsors and topic choice. Quantitative studies such as this one should attempt to operationalize more nuanced and realistic constructs of what control could mean in particular fields. Qualitative studies could better explore the phenomena of control, or examine different theories of control in more depth, while case studies could capture the processes and events that precede and determine how topic choices are made in collaborative projects or those requiring external funding.

Regarding the faculty types, additional research, perhaps using more involved scales, or asking respondents to rank items or make forced choices among a range of options, would more reliably capture the true nature of these value systems. Further research is required to ascertain the full picture of the belief systems of academic scientists, but these data indicate that alternate normative systems have as much, or even more legitimacy than do the traditional, conventional ones.

Researchers seeking to examine the stability of the alternate normative systems could look for evidence of institutionalization such as policies, procedures, and established practices—as well as communication regarding these elements –as part of the work of faculty, departments, and disciplines. Studies could also be longitudinal in nature, looking for patterns that promote adaptation and transformation of the practice of academic science.

The field of higher education should become more conversant with the concepts from science studies about the social relations of knowledge production, and move away from a focus on context and investigate instead the content of science. We should know more about how the individual faculty, departments, labs and universities approach these innovation networks and altered expectations. Such an approach would help us better understand the nature and functioning of the large-scale collaborations and interdisciplinary research teams that constitute modern academic science.

APPENDICES

Original Survey Instrument

Appendix 1: Survey on Faculty Perspectives on Academic Science

Faculty Perspectives on Sponsored Research and Academic Science

1. Welcome and Overview

You are invited to participate in an important study about faculty work through this web survey.

This survey is designed to collect information about your attitudes and perceptions regarding the freedom you have in your research practice to study what is of most interest to you.

There are several main sections to the survey. Following some background information, the questions address external influences on your work, your involvement in commercial science, control over your research, and the intersection of academic and commercial science.

Immediately following this page, you will find statements that inform you of your rights as a research participant. Communicating this information is standard procedure in the research process. Once you review the required information, you will need to indicate that you have reviewed it before you can proceed to the survey.

If you have questions about the survey or any problems completing it, please send an email to tperoraz@umich.edu .

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Faculty Perspectives on Sponsored Research and Academic Science

2. Informed Consent

GENERAL CONSENT FOR SURVEY

FACULTY PERSPECTIVES ON SPONSORED RESEARCH, ACADEMIC SCIENCE AND RESEARCH AGENDAS

The survey is being conducted by Thomas E. Perorazio, a Ph.D. candidate at the University of Michigan. His dissertation is chaired by Eric L. Dey, Associate Professor, from the Center for the Study of Higher and Postsecondary Education (CSHPE).

Description of the Study:
This survey is designed to obtain your perspectives regarding the influence of sponsors on your research practice and the intersection of academic and commercial science. Following background information, there are questions about your involvement with commercial science, the process of negotiating with sponsors regarding research topics, and a section with questions about common issues in relation to academic and commercial science.

You were selected from a national database of college and university faculty. The study is targeting approximately 2000 research faculty at doctoral and research universities in five broad disciplinary areas: Biological science, Physical science, Engineering, Medical science, and Social science. This study has received approval from the University of Michigan Institutional Review Board (HUM00015313).

Participation:
Completing the survey should take no more than 20 minutes. There are 7 sections of questions, including demographics. Answering requires only the use of a computer mouse.

Your participation in this survey is completely voluntary. Even after you indicate your informed consent below, you may decline to participate without any penalty. Also, once you have begun the survey, you may choose not to respond to any question, or cease your survey participation at anytime. Your decision to participate (or refusal to participate) will have no impact on your status at your college or university.

Participating in this survey involves minimal risk to participants (i.e. no more risk than one might experience in daily life). Any potential risks, such as breach of confidentiality, data loss, and personal harm to you are extremely unlikely. Your responses will be encrypted and stored on restricted access servers; also there are no questions covering personally or professionally sensitive topics—the items concern attitudes about your research practice and university research generally. Should you wish to complete the survey, but not do so via the web, please use the contact information below to request the survey in a different form.

All of your answers will be treated as confidential, and there is no case where responses from individual participants will be identified in any reports, presentations, or publications resulting from this research. Records will be kept confidential to the extent provided by federal, state, and local laws. However, the Institutional Review Board or university officials responsible for monitoring this study may inspect these records. Responses will be maintained by the principal investigator in a database for future research and publication.

Benefit:
This study examines the issue of whether research faculty have the resources and freedom to research what is of most interest to them, or if this ability is hindered because the process of locating external funding, and the providers of that funding, are either limiting or directly controlling the research agenda. Also, the study explores the larger question of the changing nature of academic science through the examination of faculty values, attitudes, and practices within these circumstances.

Contact Information:
Thomas E. Perorazio, a Ph.D. candidate at the University of Michigan, can be contacted at: The University of Michigan, Center for the Study of Higher and Postsecondary Education, 610 E. University, 2117 School of Education, Ann Arbor, MI 48109-1259, (734)476-1222, email: tperoraz@umich.edu . Dr. Eric L. Dey can be reached by phone at 734-647-1651 and via email at dey@umich.edu.

Faculty Perspectives on Sponsored Research and Academic Science

*** 1. CONSENT**

I acknowledge that I am 18 years of age or older, understand the statements above, and freely consent to participate in the study.

Click on the "I Agree" button to begin the survey.

◯ I Agree

◯ I Do Not Agree

Faculty Perspectives on Sponsored Research and Academic Science

3. Completing the Survey

Thank you for agreeing to complete the survey!

This questionnaire consists of 6 major question areas, plus a short demographics section. It should take approximately 20 minutes to complete.

Each major section of the survey addresses different aspects of the intersection of academic and commercial science and inquires about some of the factors influencing the conduct of your research. This includes your involvement with commercial science, as well as external influences from your university, discipline, and research sponsors.

These issues are important because of disagreement within higher education about the influence of research sponsors on research practice. Central to the entire survey are two concepts: 1) the freedom you believe you have to research what is of most interest to you and 2) the extent, if any, to which you perceive academic science to be influenced by commercial science. You should respond based on your personal experiences; there are no right or wrong answers.

If at any time you feel that you are not able to answer a question, you may simply skip it or indicate that you have no basis to provide an answer and then continue through the rest of the survey. If you are interrupted while completing the survey, you may return to the last question you answered simply by accessing the survey through the link provided in the invitational email message.

Thanks again for your participation in this important research!

Faculty Perspectives on Sponsored Research and Academic Science

4. Professional Background

Please provide the following information about yourself:

2. What is your present academic rank?

- ◯ Professor
- ◯ Associate Professor
- ◯ Assistant Professor
- ◯ Research Scientist/ Research Professor (any rank)

Other (please specify)

3. For how many years have you been an academic?

- ◯ Less than 1 year
- ◯ 1 to 3 years
- ◯ 4 to 7 years
- ◯ 8 to 15 years
- ◯ 16 to 24 years
- ◯ 25 years or more

4. How many years--perhaps before and/or between academic appointments--have you worked primarily in industry? (Select from the menu below)

- ◯ Never worked in industry
- ◯ Worked less than 1 year
- ◯ 1 to 5 years
- ◯ 6 to 10 years
- ◯ 11 to 20 years
- ◯ 21 years or more

5. What is your current tenure status?

- ◯ Tenured
- ◯ One tenure track, but not tenured
- ◯ Not on tenure track, but institution has a tenure system
- ◯ Institution has no tenure system

Faculty Perspectives on Sponsored Research and Academic Science

6. In which of the following categories would you place your academic discipline? (Select from the menu below)

- ◯ Engineering (all types)
- ◯ Medical/ Health Sciences
- ◯ Physical Sciences
- ◯ Biological Sciences
- ◯ Social Sciences

Other (please specify)

7. Do you currently hold an administrative appointment? (Indicate Yes for all those that apply)

	Yes	No
Vice President (Executive, Associate, Assistant, or Acting)	◯	◯
Director (Executive, Associate, or Asssistant, or Acting)	◯	◯
Chair (Associate, Assistant, or Acting)	◯	◯
Dean (Associate, Assistant, or Acting)	◯	◯
Provost (Vice, Associate, Assistant, or Acting)	◯	◯
Chief/ Executive Officer	◯	◯

Other (please specify)

Faculty Perspectives on Sponsored Research and Academic Science

5. External Influences On Research Practice

This first section inquires about demands, pressures, and constraints you perceive from external influences on your research work.

8. Please indicate your level of agreement with the following statements about your home institution.
My academic institution:

	Agree Completely	Agree Generally	Ambivalent	Disagree Generally	Disagree Completely	No Basis for Judgment
Has an "entrepreneurial environment" that encourages the commercialization of research	◯	◯	◯	◯	◯	◯
Requires me to offset part of my salary with external research funds	◯	◯	◯	◯	◯	◯
Provides financial assistance to support aspects of my research program	◯	◯	◯	◯	◯	◯
Has policies that restrict publications derived from sponsored research	◯	◯	◯	◯	◯	◯
Offers procedural support for faculty involved in patenting/licensing of innovations	◯	◯	◯	◯	◯	◯
Has policies to help faculty prevent/resolve conflicts of interest/commitment	◯	◯	◯	◯	◯	◯
Rewards commercial activity in promotion/tenure decisions	◯	◯	◯	◯	◯	◯

9. This question asks about the demands and pressures you may feel from external actors, such as your research sponsors, collaborators in industry or government, and disciplinary field. For each of the actions below, please choose one response.

In my research, I feel pressure to:

	None at all	Only a little	A moderate amount	A significant amount	An overwhelming amount	No Basis for Judgment
Select topics with commercial potential	◯	◯	◯	◯	◯	◯
Focus on research with applied outcomes	◯	◯	◯	◯	◯	◯
Commercialize research results	◯	◯	◯	◯	◯	◯
Limit publication of research results	◯	◯	◯	◯	◯	◯
Generate revenues from my research	◯	◯	◯	◯	◯	◯

10. Given the opposing statements below, please indicate where you would place yourself along this dimension.

◯ The academy and industry are distinct realms ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ The academy and industry overlap

Faculty Perspectives on Sponsored Research and Academic Science

11. Given the opposing statements below, please indicate where you would place yourself along this dimension.

◯ Commercial science threatens the academy	◯ 2	◯ 3	◯ 4	◯ 5	◯ 6	◯ Commercial science does NOT threaten the academy

12. The statements below describe different levels of control over your TOPIC CHOICE in sponsored research.

Please indicate a response in the context of both federal agency/ government sponsored research and that sponsored by industry/ corporations.

Using the drop-down menus, indicate how frequently each of these scenarios applies to your research projects :

	Federal agencies/ Government	Industry/ Corporations
I am able to obtain funding from my sponsors to research the topics I choose based SOLELY on my interests		
I collaborate with sponsors and agree to conduct research on topics of mutual interest before receiving funds		
I am compelled to yield significant aspects of topic selection to sponsors before receiving funds		
Sponsor influence is such that funding can only occur by acceding to ALL their demands regarding topic choice		

13. In your own mind, what constitutes having control over your research agenda in terms of sponsored research?

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6. Personal Involvement In Commercial Science

These questions inquire about your levels of knowledge regarding and involvement in commercial science activities.

14. Call to mind the project or idea that you took the furthest in terms of commercial development, if applicable. Please indicate the highest level of involvement in commercial development you have experienced with an academic invention:

	Yes	No
No invention/Took no action	◯	◯
Published findings, gave invention to sponsor	◯	◯
Submitted invention disclosure	◯	◯
Applied for patent	◯	◯
Obtained patent	◯	◯
Licensed invention	◯	◯
Received royalty income	◯	◯
Started company based on invention	◯	◯

Other (please specify)

15. Please indicate whether or not you have any involvement in the following commercial activities:
(check all that apply)

	Yes	No
Consulting for industry	◯	◯
Industrial advisory boards	◯	◯
Small Business Development Centers	◯	◯
University-based industry research centers	◯	◯
Collaborative research activity/partnerships with a company	◯	◯
Industrial research parks	◯	◯
Negotiations regarding the licensing/patenting of university discoveries	◯	◯
Researcher exchange programs between universities and industry	◯	◯
Entrepreneurship (Start-ups/Spin-offs)	◯	◯
Business Incubators	◯	◯

16. With the activities in the TWO previous questions as reference, at what level would you place your current knowledge of the processes for the commercialization of academic research :

- ◯ No knowledge
- ◯ Vague knowledge
- ◯ Reasonable knowledge
- ◯ Substantial knowledge
- ◯ Sophisticated knowledge

Other (please specify)

17. To the best of your ability, please indicate the percentages of your current sponsored research support that comes from the following sources: (Total should sum to 100%)

Government (Fed and/or state) / Public agencies	
Industry/ Business/ Corporations	
Foundations/ Private organizations/ Associations	
University support	
Other	

Faculty Perspectives on Sponsored Research and Academic Science

7. Control Over Research Agenda

The questions in this section deal with the potential influences on your choice of research topics/projects, particularly that of sponsors and the potential for commercial results.

18. These items concern different potential outcomes involving sponsored research. Please indicate their frequency from your perspective:

	Always	Usually	Occasionally	Rarely	Never
I am able to find research funding for the questions I wish to pursue	◯	◯	◯	◯	◯
Sponsors of research actively attempt to influence my choice of research topics	◯	◯	◯	◯	◯
Inability to find funding keeps me from pursuing the problems of greatest interest to me	◯	◯	◯	◯	◯
I am able to fit my research questions into the project goals of my funding providers	◯	◯	◯	◯	◯
I alter the focus of my research to accommodate the project goals of my research sponsors	◯	◯	◯	◯	◯
Researching topics of interest to my research sponsors keeps me from studying topics important to me	◯	◯	◯	◯	◯
My research sponsors have specific problems they want me to research for them	◯	◯	◯	◯	◯
I convince research sponsors that my research questions will advance their interests	◯	◯	◯	◯	◯
I have to compromise my research interests in order to secure funding for any research	◯	◯	◯	◯	◯
Research sponsors ask me to make my research more commercial	◯	◯	◯	◯	◯
I am concerned that my commercial activity will compromise my ability to conduct objective science	◯	◯	◯	◯	◯
I am restricted from conducting basic research with the funding I am able to raise	◯	◯	◯	◯	◯

Faculty Perspectives on Sponsored Research and Academic Science

8. Academic and Commercial Science (Page 1 of 2)

This portion of the survey consists of statements concerning the conduct of academic of science in relation to six topic areas. You are asked to indicate your level of agreement.

Following some general statements, there are sections specifically regarding funding, basic v. applied science, publishing/patenting, conflicts of interest, and criteria for good science.

Thinking about your own situation and these issues relating to academic science, to what extent do you agree with these statements?

19. GENERAL QUESTIONS:

Please indicate your level of agreement with these statements regarding academic and commercial science.

	Agree Completely	Agree Generally	Ambivalent	Disagree Generally	Disagree Completely	No Basis for Judgment
The maintenance of academic values is an individual responsibility and thus not a matter for university policy	◯	◯	◯	◯	◯	◯
Faculty should advance their own individual academic and commercial goals independent of formal partnerships with business entities	◯	◯	◯	◯	◯	◯
Academic rewards and commercial involvement can be mutually reinforcing in the pursuit of quality science	◯	◯	◯	◯	◯	◯
The temptation of commercial rewards from industry is endangering academia by luring away the best talent	◯	◯	◯	◯	◯	◯
Partnerships with commercial firms enhances the unique position universities have as creators of good science	◯	◯	◯	◯	◯	◯
University-level oversight of commercial partnerships is required to protect against relative faculty inexperience regarding patenting/licensing	◯	◯	◯	◯	◯	◯

20. FUNDING:

	Agree Completely	Agree Generally	Ambivalent	Disagree Generally	Disagree Completely	No Basis for Judgment
Private industry contracts should only be obtained as necessary to advance academic science	◯	◯	◯	◯	◯	◯
Private industry contracts can advance academic science with as much legitimacy as government grants	◯	◯	◯	◯	◯	◯
Funding academic research with government grants is the best way to preserve faculty autonomy	◯	◯	◯	◯	◯	◯
Both government grants and private contracts come with legitimate restrictions that faculty must negotiate	◯	◯	◯	◯	◯	◯

21. BASIC/ APPLIED RESEARCH:

	Agree Completely	Agree Generally	Ambivalent	Disagree Generally	Disagree Completely	No Basis for Judgment
Applied research should be the domain of government and industry scientists, not academics	◯	◯	◯	◯	◯	◯
Engaging into commercial activity is necessary to protect academic research from further encroachment by industry	◯	◯	◯	◯	◯	◯
Faculty are able to conduct commercial research while maintaining traditional academic values	◯	◯	◯	◯	◯	◯
Distinctions between pure & applied research are no longer important; Topic significance is a more vital research consideration	◯	◯	◯	◯	◯	◯

Faculty Perspectives on Sponsored Research and Academic Science

9. Academic and Commercial Science (Page 2 of 2)

This portion of the survey consists of statements concerning the conduct of academic of science in relation to six topic areas. You are asked to indicate your level of agreement.

Following some general statements, there are sections specifically regarding funding, basic v. applied science, publishing/patenting, conflicts of interest, and criteria for good science.

Thinking about your own situation and these issues relating to academic science, to what extent do you agree with these statements?

22. PUBLISHING/ PATENTING:

	Agree Completely	Agree Generally	Ambivalent	Disagree Generally	Disagree Completely	No Basis for Judgment
Academics should favor publication of results over any intellectual property protections	◯	◯	◯	◯	◯	◯
Patents and restrictions on private intellectual property are needed to protect academic science from industry	◯	◯	◯	◯	◯	◯
Publication restrictions are legitimately needed to protect research sponsors	◯	◯	◯	◯	◯	◯
Patenting, and intellectual property restrictions are legitimate parts of research collaborations with industry/agencies	◯	◯	◯	◯	◯	◯

23. CONFLICTS OF INTEREST/COMMITMENT:

	Agree Completely	Agree Generally	Ambivalent	Disagree Generally	Disagree Completely	No Basis for Judgment
Involvement with commercial activities fundamentally alters the academic environment for openness	◯	◯	◯	◯	◯	◯
Potential conflicts can best be addressed by individual faculty through negotiations with research sponsors	◯	◯	◯	◯	◯	◯
Academic recognition and commercial success are independent reward systems	◯	◯	◯	◯	◯	◯
University policies prevent conflicts of interest better than training individual faculty on industry engagement	◯	◯	◯	◯	◯	◯

24. CRITERIA FOR GOOD, QUALITY SCIENCE:

	Agree Completely	Agree Generally	Ambivalent	Disagree Generally	Disagree Completely	No Basis for Judgment
Success should be evaluated primarily on traditional criteria like publications and contributions to the field	◯	◯	◯	◯	◯	◯
Success can be viewed as disseminating results and innovations through publications and patents	◯	◯	◯	◯	◯	◯
Success can be measured by either academic achievement or significant commercial involvement, such as patenting	◯	◯	◯	◯	◯	◯
Success comes from applying academic research to solve important practical problems	◯	◯	◯	◯	◯	◯

Faculty Perspectives on Sponsored Research and Academic Science

10. Demographics

25. Please indicate your gender:

- ◯ Male
- ◯ Female

26. Please indicate your preferred racial/ ethnic designation:

- ☐ White
- ☐ Black
- ☐ American Indian/Alaskan Native
- ☐ Asian American/ Asian
- ☐ Latino/Chicano
- ☐ Native Hawaiian/ Pacific Islander
- ☐ North African/ Middle Eastern

Other (please specify)

27. What is your home academic institution ?

(This information will be used ONLY to gather additional data about your institution, such as total research expenditures and expenditures by source of funds, from the National Science Foundation (NSF) and the Integrated Postsecondary Education Data System (IPEDS.)

Faculty Perspectives on Sponsored Research and Academic Science

11. Exit the Survey

Thanks for your time and consideration of this survey. All responses will contribute to the study of commercial science and the influence of industry on the academy.

A brief summary of the results and findings from this study will be made available to all respondents during the spring of 2009.

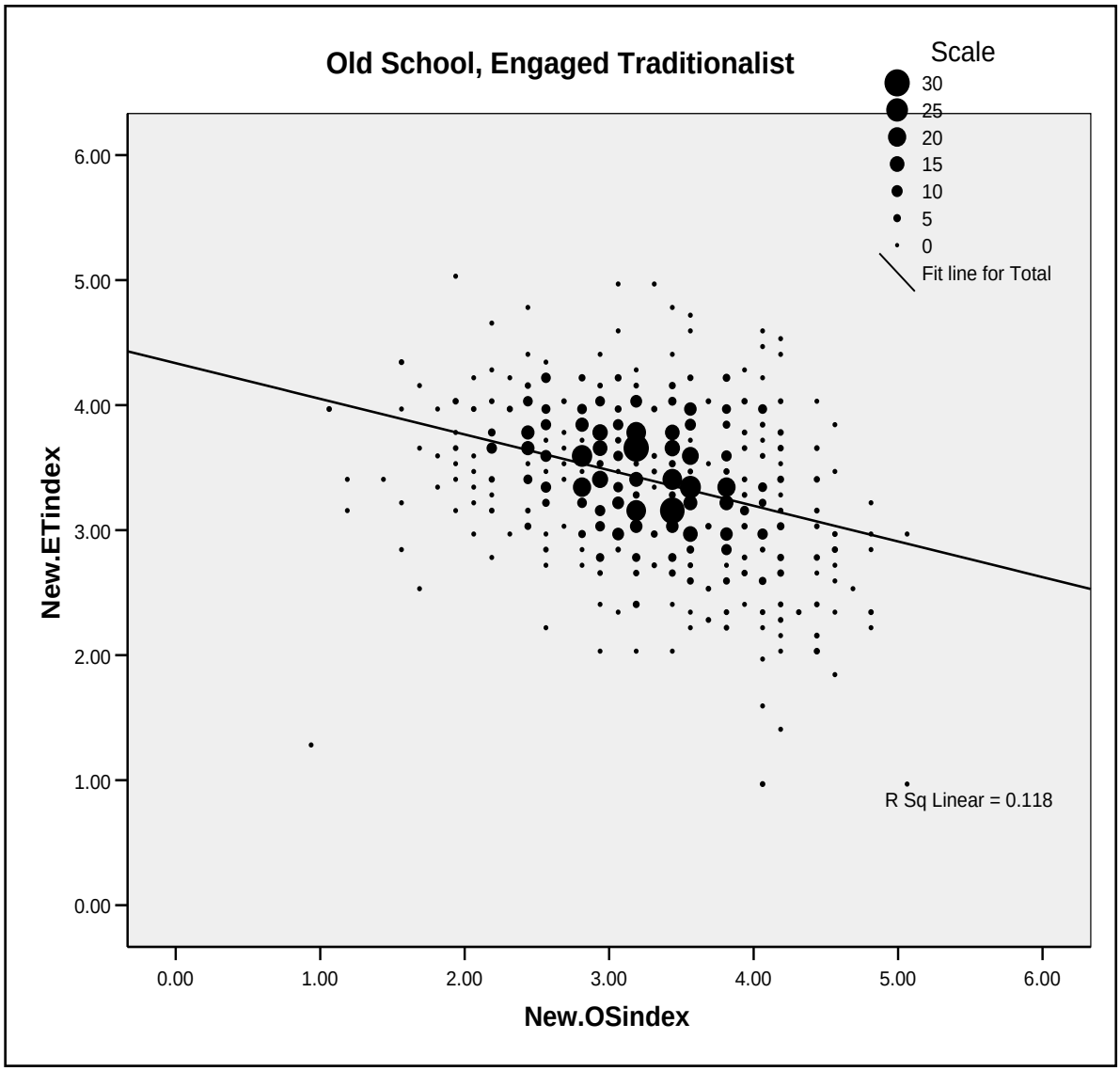
You can exit this survey by using the "Exit" link in the top right corner of this page.

28. If you prefer an electronic version of the survey, which can either be printed and mailed back, or completed and returned via email, please provide your name and email address below.

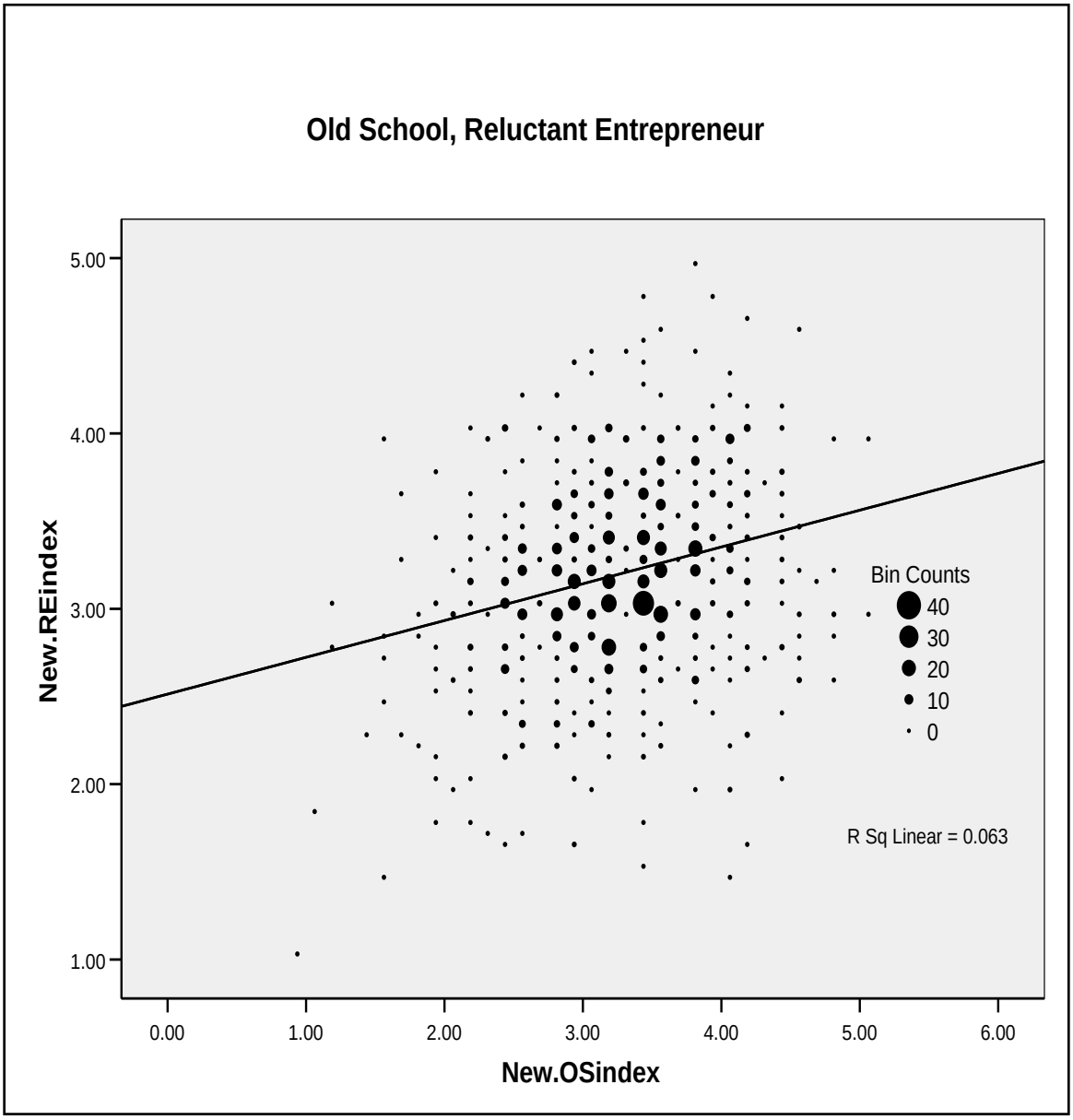
Name:

E-mail:

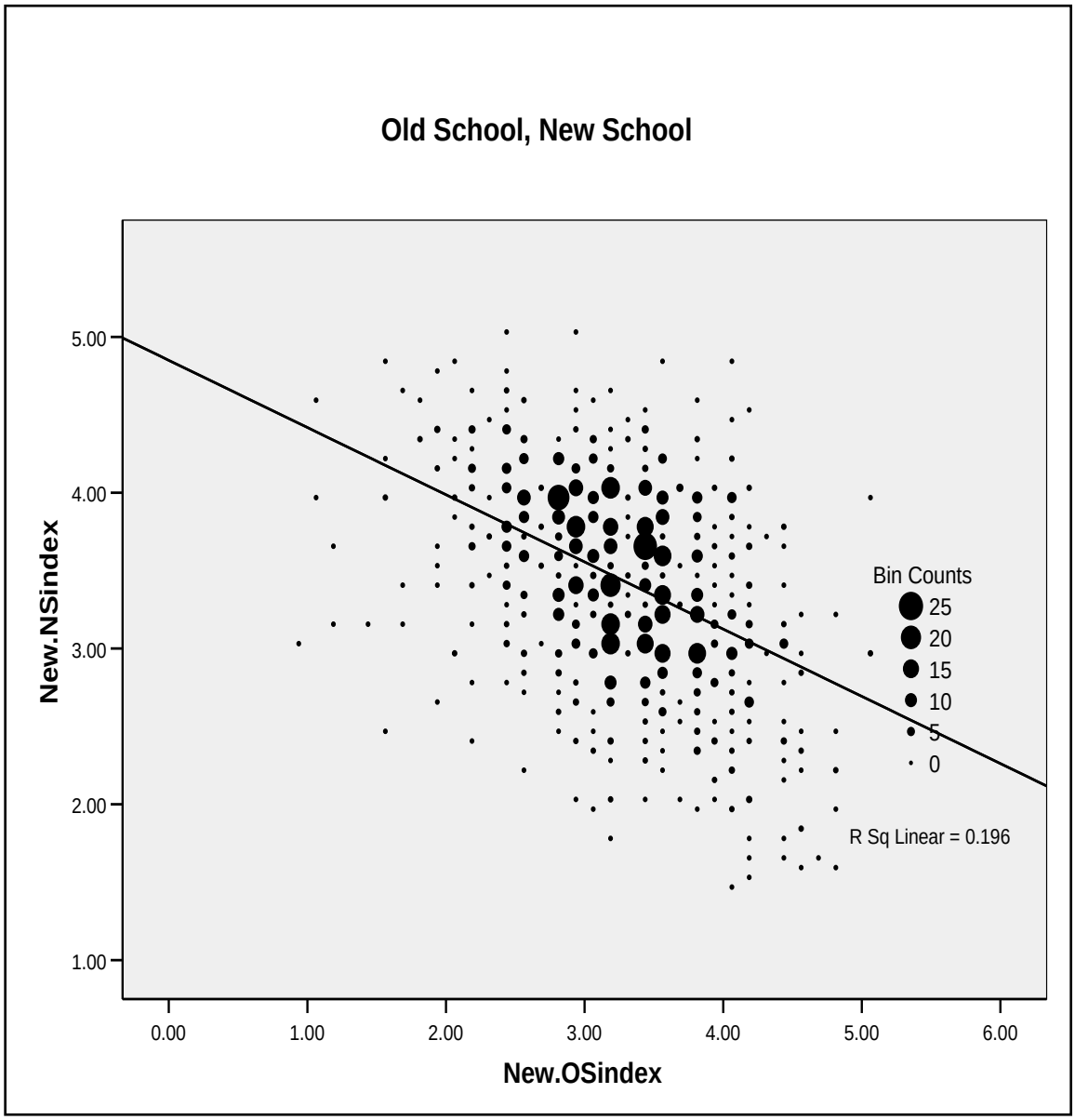
Appendix 2: Graph of Old School, Engaged Traditionalist



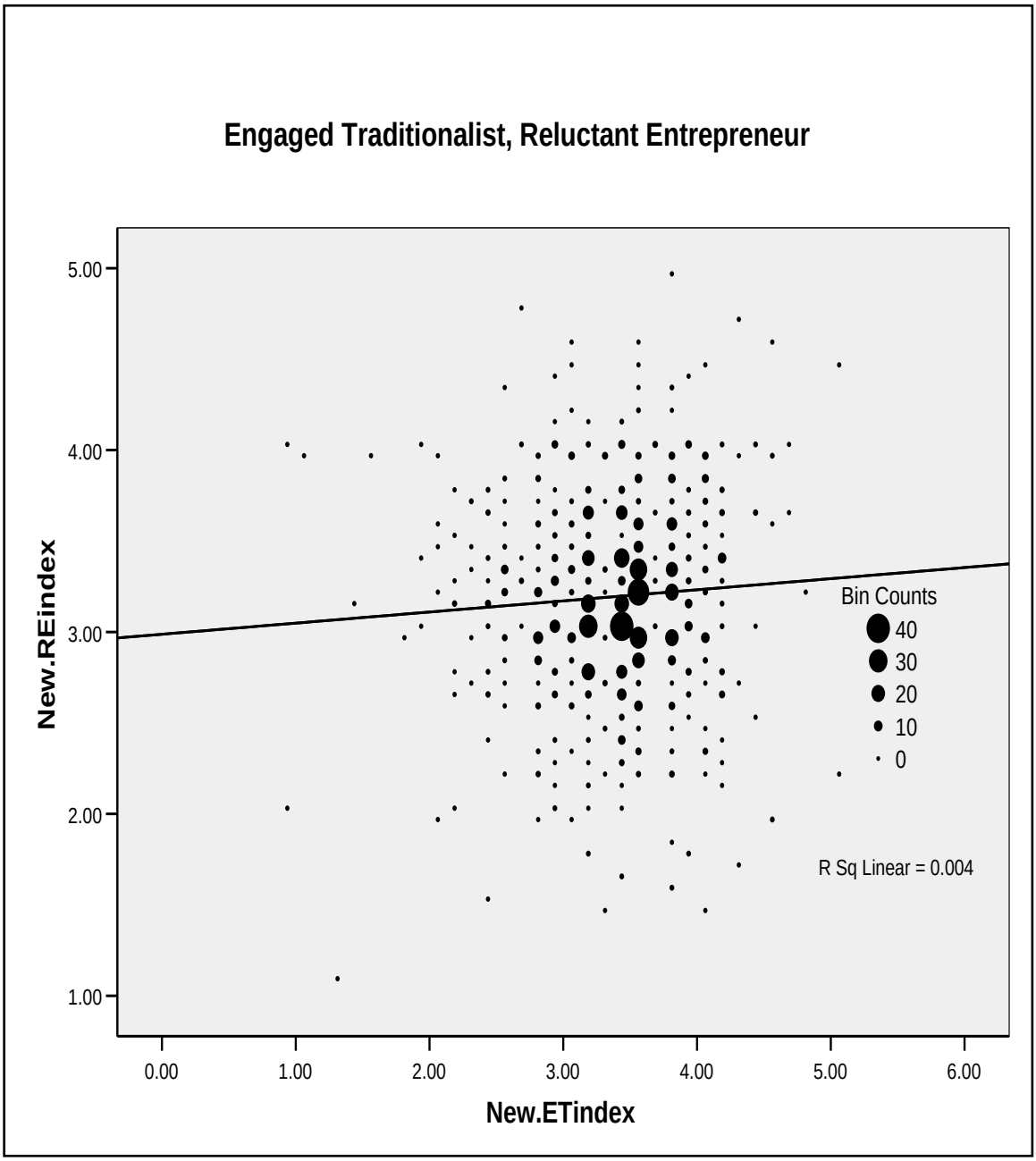
Appendix 3: Graph of Old School, Reluctant Entrepreneur



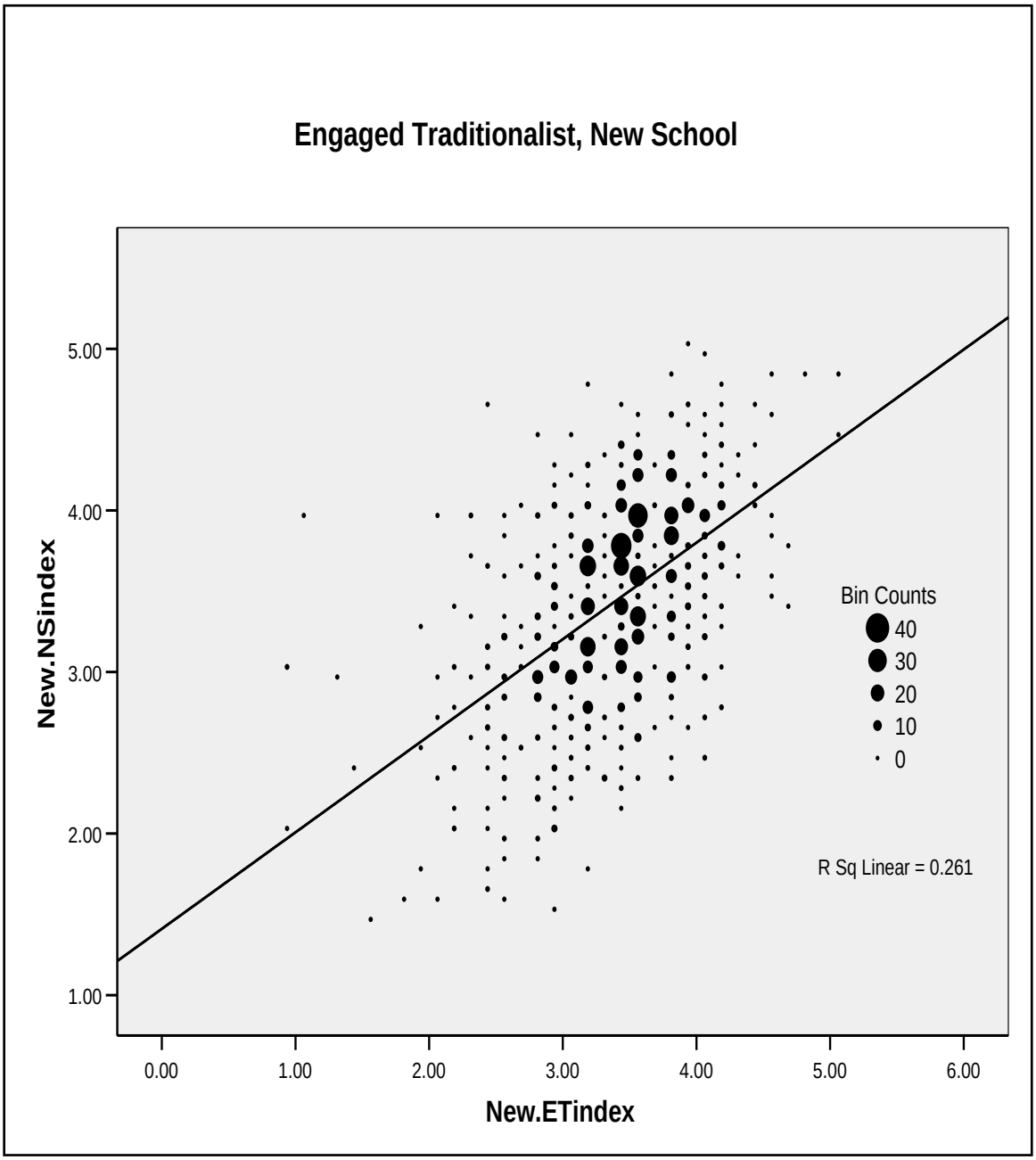
Appendix 4: Graph of Old School, New School



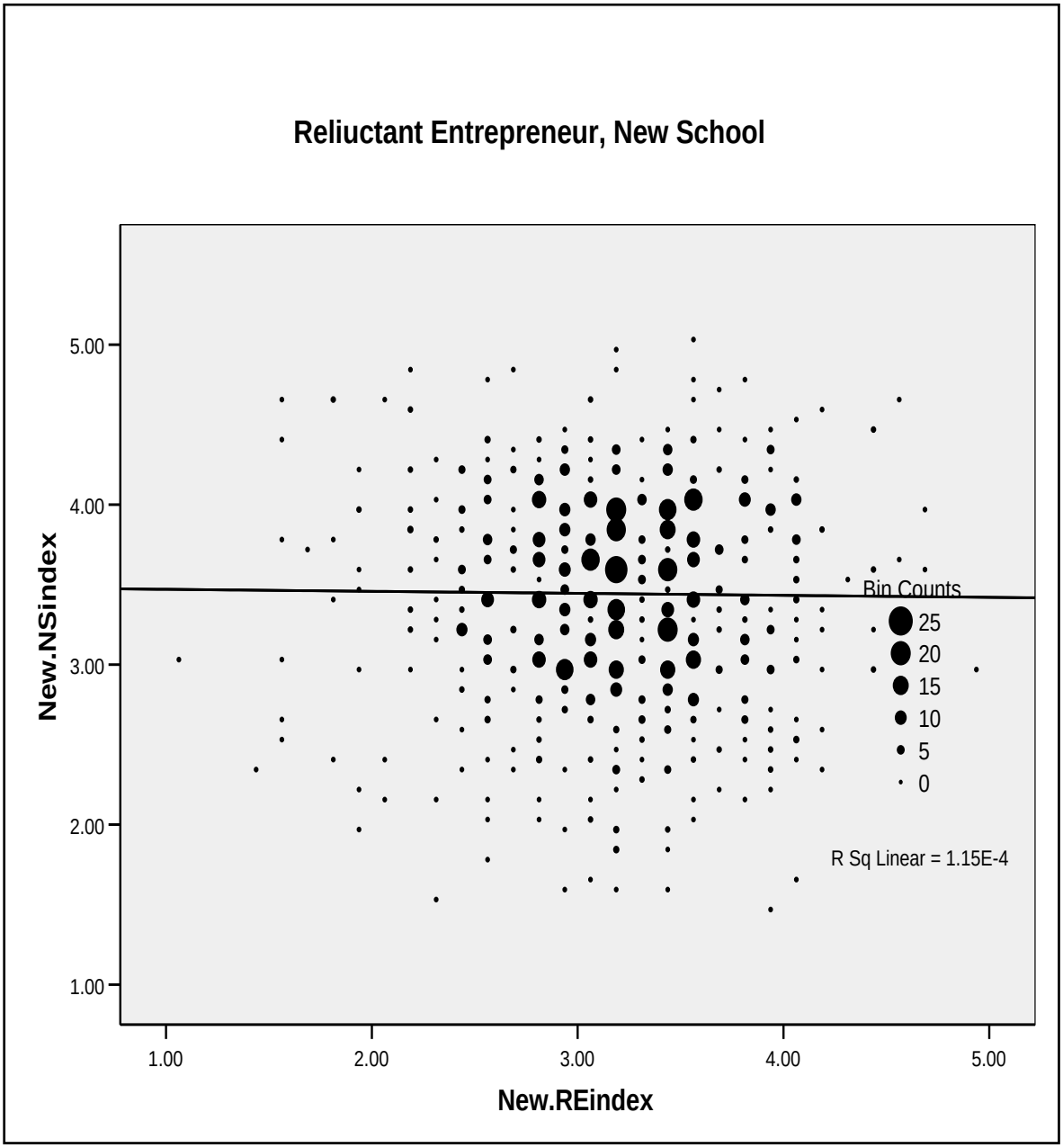
Appendix 5: Graph of Engaged Traditionalist, Reluctant Entrepreneur



Appendix 6: Graph of Engaged Traditionalist, New School



Appendix 7: Graph of Reluctant Entrepreneur, New School



Appendix 8: Regression Model Predicting Curiosity and Government Sponsorship

	B	SEB	Beta	Sig.	
DEMOGRAPHICS					
Gender	.023	.068	.011	.733	
CAREER					
8-15 Years in academia *(Ref = 0 -7)*	-.001	.081	-.001	.988	
16-24 Years in academia	.145	.086	.060	.091	
25-plus Years in academia	.256	.091	.101	.005	**
Less than 1 Yr worked in Industry *(Ref= None)*	-.066	.111	-.017	.550	
1 to 5 Yrs worked in industry	-.040	.080	-.015	.617	
6-plus Yrs worked in industry	-.101	.092	-.034	.273	
COMMERCIAL SCIENCE INVOLVEMENT					
Knowledge of Commercialization	.023	.048	.017	.633	
Highest Involvement in Commercial Science	-.001	.016	-.002	.946	
1 Commercial Science activity *(Ref = None)*	-.076	.086	-.027	.377	
2 Commercial Science activities	-.053	.047	-.036	.259	
3 Commercial Science activities	-.026	.039	-.021	.510	
4-plus Commercial Science activities	-.031	.031	-.041	.314	
INSTITUTIONAL CS ENVIRONMENT					
Pressure Select topics with commercial potential	-.075	.049	-.067	.120	
Pressure: Focus on applied outcomes	-.073	.033	-.078	.029	*
Pressure: Commercialize research results	-.037	.053	-.029	.488	
Pressure: Limit publication of results	.061	.066	.029	.353	
Pressure: Generate revenues from my research	-.102	.030	-.106	.001	**
My academic institution:					
Has entrepreneurial environment	-.003	.033	-.003	.922	
Requires salary offset w external research funds	.068	.020	.103	.001	**
Provides financial support for my research	.062	.026	.072	.017	*
Has policies to restrict publication of research results	.005	.037	.004	.894	
Has procedural support for licensing/ patents	.012	.048	.009	.801	
Has policies to resolve conflicts of interest	.044	.043	.033	.298	
Rewards commercial science activity in P & T decisions	-.021	.034	-.019	.534	
SOURCE OF SUPPORT					
Current sponsorship: Government-Public agencies	.004	.001	.143	.000	***
Current sponsorship: Industry-Corporations	-.005	.002	-.078	.017	*
Current sponsorship: Foundations	.001	.002	.009	.769	
Current sponsorship: University	-.001	.001	-.039	.286	
Current sponsorship: Other	-.005	.002	-.075	.011	*
FACULTY TYPE PREFERENCES					
Old School	.110	.061	.061	.070	
Engaged Traditionalist	.083	.071	.038	.246	
Reluctant Entrepreneur	.053	.065	.024	.415	
New School	-.002	.063	-.001	.969	
ACADEMIC DISCIPLINE (Ref = Social Science)					
Engineering	.092	.117	.030	.429	
Medical/ Health Sciences	.059	.047	.048	.206	
Physical Sciences	.060	.034	.065	.078	
Biological Sciences	.051	.025	.078	.036	*

	B	SEB	Beta	Sig.
INSTITUTIONAL TYPE (Ref = Very High Research Activity)	-.084	.068	-.036	.214
Type-High research activity	-.030	.046	-.020	.509
Type – Doctoral/Research Univ	.059	.083	.022	.479
Control *(Ref = Public)*				
Research Expenditures (Pctg.)				
Federal Government	-.005	.006	-.079	.342
State Government	.000	.007	.000	.997
Industry	.002	.007	.013	.745
Institutional Funds	-.007	.006	-.087	.227
(constant)	2.98	0.68		.000
R^2	0.163			
Adjusted R^2	0.131			
Standard Error	0.980			
F	5.053			0.00

Note: (N = 1,210; * p < .05, ** p < .01, *** p < .001)

Appendix 9: Regression Model Predicting Curiosity for Industry Sponsorship

	B	SEB	Beta	Sig.	
DEMOGRAPHICS					
Gender	-.029	.065	-.015	.651	
CAREER					
8-15 Years in academia *(Ref = 0 -7)*	.001	.077	.000	.992	
16-24 Years in academia	.122	.082	.054	.136	
25-plus Years in academia	.118	.087	.050	.176	
Less than 1 Yr worked in Industry *(Ref= None)*	-.058	.106	-.016	.587	
1 to 5 Yrs worked in industry	.026	.077	.010	.733	
6-plus Yrs worked in industry	.050	.088	.018	.571	
COMMERCIAL SCIENCE INVOLVEMENT					
Knowledge of Commercialization	.061	.046	.049	.186	
Highest Involvement in Commercial Science	.002	.015	.005	.894	
1 Commercial Science activity *(Ref = None)*	.069	.082	.027	.399	
2 Commercial Science activities	.034	.045	.025	.449	
3 Commercial Science activities	.106	.038	.092	.005	**
4-plus Commercial Science activities	.101	.030	.139	.001	**
INSTITUTIONAL CS ENVIRONMENT					
Pressure Select topics with commercial potential	-.091	.047	-.086	.051	
Pressure: Focus on applied outcomes	-.037	.032	-.042	.247	
Pressure: Commercialize research results	.016	.051	.013	.753	
Pressure: Limit publication of results	-.058	.063	-.029	.359	
Pressure: Generate revenues from my research	.010	.028	.011	.715	
My academic institution:					
Has entrepreneurial environment	-.002	.032	-.002	.957	
Requires salary offset w external research funds	.016	.019	.026	.396	
Provides financial support for my research	.039	.025	.047	.121	
Has policies to restrict publication of research results	.081	.036	.066	.023	*
Has procedural support for licensing/ patents	-.008	.046	-.006	.857	
Has policies to resolve conflicts of interest	.075	.041	.060	.067	
Rewards commercial science activity in P & T decisions	-.063	.032	-.060	.052	
SOURCE OF SUPPORT					
Current sponsorship: Government-Public agencies	-.002	.001	-.090	.028	*
Current sponsorship: Industry-Corporations	.006	.002	.087	.009	**
Current sponsorship: Foundations	.002	.002	.038	.229	
Current sponsorship: University	-.002	.001	-.052	.166	
Current sponsorship: Other	-.001	.002	-.016	.598	
FACULTY TYPE PREFERENCES					
Old School	-.002	.058	-.001	.977	
Engaged Traditionalist	-.007	.068	-.003	.924	
Reluctant Entrepreneur	-.015	.062	-.007	.815	
New School	.120	.061	.069	.048	*
ACADEMIC DISCIPLINE (Ref = Social Science)					
Engineering	.012	.112	.004	.916	
Medical/ Health Sciences	.153	.045	.131	.001	**
Physical Sciences	-.015	.033	-.017	.648	
Biological Sciences	.031	.024	.050	.191	
INSTITUTIONAL TYPE (Ref = Very High Research Activity)					
Type-High research activity	.019	.065	.009	.770	
Type – Doctoral/Research Univ	.008	.044	.006	.851	
Control *(Ref = Public)*	.139	.079	.056	.080	

	B	SEB	Beta	Sig.
Research Expenditures (Pctg.)				
Federal Government	.000	.005	-.003	.973
State Government	.010	.006	.082	.104
Industry	.011	.007	.070	.099
Institutional Funds	.003	.006	.043	.556
(constant)	1.270	.647		.050
R^2	0.131			
Adjusted R^2	0.098			
Standard Error	0.939			
F	3.914			.000

Note: (N = 1,210; * p < .05, ** p < .01, *** p < .001)

Appendix 10: Regression Model Predicting Collaborate for Government Sponsorship

	B	SEB	Beta	Sig.	
DEMOGRAPHICS					
Gender	-.071	.085	-.027	.404	
CAREER					
8-15 Years in academia *(Ref = 0 -7)*	-.155	.101	-.053	.124	
16-24 Years in academia	-.096	.107	-.032	.370	
25-plus Years in academia	-.058	.114	-.019	.608	
Less than 1 Yr worked in Industry *(Ref= None)*	.177	.138	.038	.200	
1 to 5 Yrs worked in industry	.202	.100	.060	.044	*
6-plus Yrs worked in industry	.257	.115	.071	.025	*
COMMERCIAL SCIENCE INVOLVEMENT					
Knowledge of Commercialization	.254	.060	.156	.000	***
Highest Involvement in Commercial Science	-.007	.020	-.013	.715	
1 Commercial Science activity *(Ref = None)*	.130	.107	.038	.225	
2 Commercial Science activities	-.021	.059	-.011	.723	
3 Commercial Science activities	.016	.049	.010	.746	
4-plus Commercial Science activities	.005	.039	.006	.893	
INSTITUTIONAL CS ENVIRONMENT					
Pressure Select topics with commercial potential	.030	.061	.022	.621	
Pressure: Focus on applied outcomes	-.035	.041	-.031	.395	
Pressure: Commercialize research results	.037	.066	.024	.576	
Pressure: Limit publication of results	.026	.083	.010	.749	
Pressure: Generate revenues from my research	.068	.037	.058	.065	
My academic institution:					
Has entrepreneurial environment	.011	.041	.009	.794	
Requires salary offset w external research funds	.040	.025	.048	.116	
Provides financial support for my research	.038	.032	.036	.240	
Has policies to restrict publication of research results	.103	.047	.064	.028	*
Has procedural support for licensing/ patents	-.078	.060	-.045	.193	
Has policies to resolve conflicts of interest	.005	.053	.003	.922	
Rewards commercial science activity in P & T decisions	.028	.042	.020	.511	
SOURCE OF SUPPORT					
Current sponsorship: Government-Public agencies	.002	.001	.063	.120	
Current sponsorship: Industry-Corporations	.004	.003	.044	.182	
Current sponsorship: Foundations	-.002	.002	-.029	.346	
Current sponsorship: University	-.001	.001	-.026	.480	
Current sponsorship: Other	-.006	.003	-.066	.027	*
FACULTY TYPE PREFERENCES					
Old School	-.087	.076	-.039	.253	
Engaged Traditionalist	.105	.089	.039	.238	
Reluctant Entrepreneur	.037	.081	.014	.650	
New School	.210	.079	.091	.008	**
ACADEMIC DISCIPLINE (Ref = Social Science)					
Engineering	.057	.146	.015	.698	
Medical/ Health Sciences	-.050	.059	-.033	.393	
Physical Sciences	.041	.042	.036	.339	
Biological Sciences	-.010	.031	-.013	.738	
INSTITUTIONAL TYPE (Ref = Very High Research Activity)					
Type-High research activity	.081	.085	.028	.336	
Type – Doctoral/Research Univ	-.077	.057	-.041	.177	
Control *(Ref = Public)*	-.054	.103	-.016	.603	

	B	SEB	Beta	Sig.
Research Expenditures (Pctg.)				
Federal Government	.007	.007	.078	.352
State Government	.000	.008	-.002	.972
Industry	.016	.009	.074	.077
Institutional Funds	.007	.008	.067	.353
(constant)	.156	.843		.853
R^2	0.142			
Adjusted R^2	0.109			
Standard Error	1.225			
F	4.293			.000

Note: (N = 1,210; * p < .05, ** p < .01, *** p < .001)

Appendix 11: Regression Model Predicting Collaborate for Industry Sponsorship

	B	SEB	Beta	Sig.	
DEMOGRAPHICS					
Gender	-.038	.076	-.015	.618	
CAREER					
8-15 Years in academia *(Ref = 0 -7)*	.061	.090	.022	.494	
16-24 Years in academia	.047	.096	.016	.625	
25-plus Years in academia	.042	.101	.014	.677	
Less than 1 Yr worked in Industry *(Ref= None)*	.033	.123	.007	.788	
1 to 5 Yrs worked in industry	.031	.089	.010	.726	
6-plus Yrs worked in industry	.099	.103	.028	.337	
COMMERCIAL SCIENCE INVOLVEMENT					
Knowledge of Commercialization	.144	.053	.092	.007	**
Highest Involvement in Commercial Science	.025	.018	.046	.155	
1 Commercial Science activity *(Ref = None)*	.135	.096	.041	.157	
2 Commercial Science activities	.125	.053	.070	.018	**
3 Commercial Science activities	.089	.044	.061	.043	*
4-plus Commercial Science activities	.156	.035	.169	.000	***
INSTITUTIONAL CS ENVIRONMENT					
Pressure Select topics with commercial potential	.001	.054	.001	.989	
Pressure: Focus on applied outcomes	-.012	.037	-.011	.751	
Pressure: Commercialize research results	.090	.059	.060	.127	
Pressure: Limit publication of results	-.004	.074	-.002	.952	
Pressure: Generate revenues from my research	.054	.033	.047	.104	
My academic institution:					
Has entrepreneurial environment	.060	.037	.051	.103	
Requires salary offset w external research funds	.013	.022	.017	.550	
Provides financial support for my research	.064	.029	.062	.027	*
Has policies to restrict publication of research results	.046	.042	.030	.271	
Has procedural support for licensing/ patents	.038	.053	.022	.480	
Has policies to resolve conflicts of interest	.030	.047	.019	.528	
Rewards commercial science activity in P & T decisions	-.105	.038	-.080	.005	**
SOURCE OF SUPPORT					
Current sponsorship: Government-Public agencies	-.001	.001	-.037	.322	
Current sponsorship: Industry-Corporations	.013	.002	.157	.000	***
Current sponsorship: Foundations	-.003	.002	-.048	.093	
Current sponsorship: University	-.002	.001	-.059	.085	
Current sponsorship: Other	-.005	.002	-.059	.032	*
FACULTY TYPE PREFERENCES					
Old School	-.029	.068	-.013	.674	
Engaged Traditionalist	.124	.079	.048	.118	
Reluctant Entrepreneur	.048	.073	.018	.510	
New School	.062	.071	.028	.381	
ACADEMIC DISCIPLINE (Ref = Social Science)					
Engineering	.402	.130	.109	.002	**
Medical/ Health Sciences	.011	.052	.007	.839	
Physical Sciences	.068	.038	.062	.073	
Biological Sciences	.059	.027	.075	.032	*
INSTITUTIONAL TYPE (Ref = Very High Research Activity)					
Type-High research activity	.019	.075	.007	.800	
Type – Doctoral/Research Univ	-.044	.051	-.025	.385	
Control *(Ref = Public)*	.013	.092	.004	.885	
Research Expenditures (Pctg.)					
Federal Government	.012	.006	.143	.066	
State Government	.018	.007	.109	.018	*
Industry	.016	.008	.078	.045	*
Institutional Funds	.012	.007	.115	.088	

	B	SEB	Beta	Sig.
(constant)	-.450	.753		.551
R^2	0.265			
Adjusted R^2	0.237			
Standard Error	1.094			
F	9.237			.000

Note: (N = 1,210; * p < .05, ** p < .01, *** p < .001)

Appendix 12: Regression Model Predicting Compromise for Government Sponsorship

	B	SEB	Beta	Sig.	
DEMOGRAPHICS					
Gender	.028	.084	.011	.744	
CAREER					
8-15 Years in academia *(Ref = 0 -7)*	.222	.100	.078	.027	*
16-24 Years in academia	.075	.107	.025	.481	
25-plus Years in academia	.150	.113	.049	.185	
Less than 1 Yr worked in Industry *(Ref= None)*	.036	.137	.008	.794	
1 to 5 Yrs worked in industry	-.039	.099	-.012	.694	
6-plus Yrs worked in industry	-.211	.114	-.059	.066	
COMMERCIAL SCIENCE INVOLVEMENT					
Knowledge of Commercialization	-.142	.060	-.088	.018	*
Highest Involvement in Commercial Science	.019	.020	.034	.338	
1 Commercial Science activity *(Ref = None)*	-.147	.107	-.044	.168	
2 Commercial Science activities	-.001	.059	.000	.989	
3 Commercial Science activities	-.006	.049	-.004	.909	
4-plus Commercial Science activities	-.058	.039	-.061	.137	
INSTITUTIONAL CS ENVIRONMENT					
Pressure Select topics with commercial potential	-.101	.060	-.074	.095	
Pressure: Focus on applied outcomes	-.094	.041	-.083	.023	*
Pressure: Commercialize research results	-.067	.066	-.044	.307	
Pressure: Limit publication of results	.019	.082	.007	.821	
Pressure: Generate revenues from my research	-.005	.037	-.004	.902	
My academic institution:					
Has entrepreneurial environment	-.018	.041	-.015	.657	
Requires salary offset w external research funds	-.075	.025	-.093	.003	**
Provides financial support for my research	.040	.032	.038	.217	
Has policies to restrict publication of research results	-.053	.046	-.033	.257	
Has procedural support for licensing/ patents	.020	.059	.012	.739	
Has policies to resolve conflicts of interest	.029	.053	.018	.583	
Rewards commercial science activity in P & T decisions	-.031	.042	-.023	.457	
SOURCE OF SUPPORT					
Current sponsorship: Government-Public agencies	-.001	.001	-.031	.443	
Current sponsorship: Industry-Corporations	-.003	.003	-.037	.266	
Current sponsorship: Foundations	-.001	.002	-.011	.731	
Current sponsorship: University	.000	.001	.005	.888	
Current sponsorship: Other	.003	.003	.041	.175	
FACULTY TYPE PREFERENCES					
Old School	.002	.076	.001	.975	
Engaged Traditionalist	-.095	.088	-.036	.283	
Reluctant Entrepreneur	-.227	.081	-.085	.005	**
New School	-.012	.079	-.005	.881	
ACADEMIC DISCIPLINE (Ref = Social Science)					
Engineering	-.171	.145	-.045	.238	
Medical/ Health Sciences	.079	.058	.052	.179	
Physical Sciences	-.006	.042	-.005	.884	
Biological Sciences	.015	.030	.019	.625	
INSTITUTIONAL TYPE (Ref = Very High Research Activity)					
Type-High research activity	-.084	.084	-.030	.320	
Type – Doctoral/Research Univ	-.085	.057	-.046	.133	
Control *(Ref = Public)*	.066	.103	.020	.519	
Research Expenditures (Pctg.)					
Federal Government	-.008	.007	-.093	.274	
State Government	-.012	.008	-.074	.140	
Industry	-.003	.009	-.015	.728	
Institutional Funds	-.004	.008	-.042	.567	

	B	SEB	Beta	Sig.
(constant)	6.322	.839		.000
R^2	0.130			
Adjusted R^2	0.096			
Standard Error	1.218			
F	3.864			.000

Note: (N = 1,210; * p < .05, ** p < .01, *** p < .001)

Appendix 13: Regression Model Predicting Compromise for Industry Sponsorship

	B	SEB	Beta	Sig.	
DEMOGRAPHICS					
Gender	.162	.074	.068	.029	*
CAREER					
8-15 Years in academia *(Ref = 0 -7)*	.110	.088	.042	.214	
16-24 Years in academia	.133	.094	.049	.156	
25-plus Years in academia	.181	.100	.064	.069	
Less than 1 Yr worked in Industry *(Ref= None)*	.048	.121	.011	.695	
1 to 5 Yrs worked in industry	.021	.088	.007	.809	
6-plus Yrs worked in industry	-.071	.101	-.022	.484	
COMMERCIAL SCIENCE INVOLVEMENT					
Knowledge of Commercialization	-.134	.052	-.091	.011	*
Highest Involvement in Commercial Science	-.011	.017	-.022	.523	
1 Commercial Science activity *(Ref = None)*	-.224	.094	-.073	.017	*
2 Commercial Science activities	-.103	.052	-.062	.047	*
3 Commercial Science activities	-.033	.043	-.024	.446	
4-plus Commercial Science activities	-.090	.034	-.104	.009	**
INSTITUTIONAL CS ENVIRONMENT					
Pressure Select topics with commercial potential	-.003	.053	-.003	.949	
Pressure: Focus on applied outcomes	-.088	.036	-.084	.016	*
Pressure: Commercialize research results	-.168	.058	-.119	.004	**
Pressure: Limit publication of results	-.086	.072	-.036	.235	
Pressure: Generate revenues from my research	.010	.032	.010	.746	
My academic institution:					
Has entrepreneurial environment	-.016	.036	-.014	.667	
Requires salary offset w external research funds	-.025	.022	-.033	.263	
Provides financial support for my research	-.044	.028	-.046	.118	
Has policies to restrict publication of research results	-.074	.041	-.051	.070	
Has procedural support for licensing/ patents	-.001	.052	.000	.992	
Has policies to resolve conflicts of interest	.043	.047	.029	.356	
Rewards commercial science activity in P & T decisions	.050	.037	.040	.176	
SOURCE OF SUPPORT					
Current sponsorship: Government-Public agencies	.000	.001	-.003	.946	
Current sponsorship: Industry-Corporations	-.002	.002	-.020	.533	
Current sponsorship: Foundations	.000	.002	.000	.996	
Current sponsorship: University	.003	.001	.075	.036	*
Current sponsorship: Other	.005	.002	.058	.045	*
FACULTY TYPE PREFERENCES					
Old School	-.157	.067	-.078	.019	*
Engaged Traditionalist	-.158	.078	-.065	.043	*
Reluctant Entrepreneur	-.067	.071	-.027	.349	
New School	.011	.069	.005	.878	
ACADEMIC DISCIPLINE (Ref = Social Science)					
Engineering	-.480	.128	-.139	.000	***
Medical/ Health Sciences	.020	.051	.014	.703	
Physical Sciences	-.041	.037	-.040	.266	
Biological Sciences	-.028	.027	-.037	.306	
INSTITUTIONAL TYPE (Ref = Very High Research Activity)					
Type-High research activity	.067	.074	.026	.367	
Type – Doctoral/Research Univ	-.011	.050	-.006	.831	
Control *(Ref = Public)*	.020	.091	.007	.822	
Research Expenditures (Pctg.)					
Federal Government	.004	.006	.047	.562	
State Government	-.003	.007	-.022	.648	
Industry	.008	.008	.042	.299	
Institutional Funds	.005	.007	.058	.409	

	B	SEB	Beta	Sig.
(constant)	5.284	.739		.000
R^2	0.196			
Adjusted R^2	0.165			
Standard Error	1.074			
F	6.300			.000

Note: (N = 1,210; * p < .05, ** p < .01, *** p < .001)

Appendix 14: Regression Model Predicting Concession for Government Funding

	B	SEB	Beta	Sig.	
DEMOGRAPHICS					
Gender	.054	.072	.024	.451	
CAREER					
8-15 Years in academia *(Ref = 0 -7)*	.200	.085	.080	.019	*
16-24 Years in academia	.105	.091	.041	.248	
25-plus Years in academia	.010	.096	.004	.921	
Less than 1 Yr worked in Industry *(Ref= None)*	.072	.117	.018	.537	
1 to 5 Yrs worked in industry	-.141	.085	-.049	.097	
6-plus Yrs worked in industry	-.257	.098	-.082	.009	**
COMMERCIAL SCIENCE INVOLVEMENT					
Knowledge of Commercialization	-.109	.051	-.078	.032	*
Highest Involvement in Commercial Science	.002	.017	.003	.925	
1 Commercial Science activity *(Ref = None)*	-.040	.091	-.014	.662	
2 Commercial Science activities	-.035	.050	-.022	.485	
3 Commercial Science activities	.045	.042	.034	.286	
4-plus Commercial Science activities	-.006	.033	-.008	.845	
INSTITUTIONAL CS ENVIRONMENT					
Pressure Select topics with commercial potential	-.166	.051	-.139	.001	**
Pressure: Focus on applied outcomes	-.058	.035	-.058	.101	
Pressure: Commercialize research results	-.060	.056	-.045	.283	
Pressure: Limit publication of results	.001	.070	.001	.984	
Pressure: Generate revenues from my research	-.052	.031	-.051	.098	
My academic institution:					
Has entrepreneurial environment	.003	.035	.003	.925	
Requires salary offset w external research funds	-.071	.021	-.101	.001	**
Provides financial support for my research	.062	.028	.067	.025	*
Has policies to restrict publication of research results	-.078	.040	-.056	.048	*
Has procedural support for licensing/ patents	.021	.051	.014	.676	
Has policies to resolve conflicts of interest	.036	.045	.026	.422	
Rewards commercial science activity in P & T decisions	-.005	.036	-.004	.897	
SOURCE OF SUPPORT					
Current sponsorship: Government-Public agencies	.000	.001	-.013	.739	
Current sponsorship: Industry-Corporations	.000	.002	.001	.966	
Current sponsorship: Foundations	.001	.002	.023	.456	
Current sponsorship: University	.001	.001	.025	.485	
Current sponsorship: Other	.001	.002	.019	.513	
FACULTY TYPE PREFERENCES					
Old School	.084	.065	.044	.194	
Engaged Traditionalist	-.041	.075	-.018	.584	
Reluctant Entrepreneur	-.183	.069	-.079	.008	**
New School	.022	.067	.011	.749	
ACADEMIC DISCIPLINE (Ref = Social Science)					
Engineering	-.202	.124	-.061	.102	
Medical/ Health Sciences	.037	.050	.028	.455	
Physical Sciences	.026	.036	.027	.464	
Biological Sciences	.021	.026	.030	.420	
INSTITUTIONAL TYPE (Ref = Very High Research Activity)					
Type-High research activity	-.010	.072	-.004	.893	
Type – Doctoral/Research Univ	.069	.048	.043	.152	
Control *(Ref = Public)*	.057	.088	.020	.517	
Research Expenditures (Pctg.)					
Federal Government	.003	.006	.042	.615	
State Government	-.003	.007	-.020	.689	
Industry	.004	.008	.023	.569	
Institutional Funds	.003	.006	.038	.598	

	B	SEB	Beta	Sig.
(constant)	4.694	.716		.000
R^2	0.169			
Adjusted R^2	0.136			
Standard Error	1.040			
F	5.244			.000

Note: (N = 1,210; * p < .05, ** p < .01, *** p < .001)

Appendix 15: Regression Model Predicting Concession for Industry Sponsorship

	B	SEB	Beta	Sig.	
DEMOGRAPHICS					
Gender	.093	.071	.041	.191	
CAREER					
8-15 Years in academia *(Ref = 0 -7)*	.105	.084	.042	.213	
16-24 Years in academia	.097	.090	.037	.280	
25-plus Years in academia	.097	.095	.036	.311	
Less than 1 Yr worked in Industry *(Ref= None)*	.005	.116	.001	.962	
1 to 5 Yrs worked in industry	-.017	.084	-.006	.841	
6-plus Yrs worked in industry	.021	.096	.007	.824	
COMMERCIAL SCIENCE INVOLVEMENT					
Knowledge of Commercialization	-.124	.050	-.088	.013	*
Highest Involvement in Commercial Science	-.016	.017	-.033	.325	
1 Commercial Science activity *(Ref = None)*	-.135	.090	-.046	.132	
2 Commercial Science activities	-.087	.050	-.054	.081	
3 Commercial Science activities	-.068	.041	-.052	.099	
4-plus Commercial Science activities	-.063	.033	-.076	.054	
INSTITUTIONAL CS ENVIRONMENT					
Pressure Select topics with commercial potential	-.172	.051	-.143	.001	**
Pressure: Focus on applied outcomes	-.027	.035	-.027	.441	
Pressure: Commercialize research results	-.091	.055	-.067	.103	
Pressure: Limit publication of results	-.044	.069	-.019	.528	
Pressure: Generate revenues from my research	.003	.031	.003	.932	
My academic institution:					
Has entrepreneurial environment	-.003	.035	-.003	.924	
Requires salary offset w external research funds	-.039	.021	-.055	.068	
Provides financial support for my research	-.002	.027	-.002	.946	
Has policies to restrict publication of research results	-.054	.039	-.039	.166	
Has procedural support for licensing/ patents	-.018	.050	-.012	.722	
Has policies to resolve conflicts of interest	.057	.045	.040	.203	
Rewards commercial science activity in P & T decisions	.064	.035	.054	.072	
SOURCE OF SUPPORT					
Current sponsorship: Government-Public agencies	.000	.001	.002	.969	
Current sponsorship: Industry-Corporations	.004	.002	.050	.122	
Current sponsorship: Foundations	.001	.002	.009	.753	
Current sponsorship: University	.003	.001	.076	.033	*
Current sponsorship: Other	.003	.002	.043	.132	
FACULTY TYPE PREFERENCES					
Old School	-.068	.064	-.035	.287	
Engaged Traditionalist	-.221	.075	-.095	.003	*
Reluctant Entrepreneur	-.114	.068	-.049	.095	
New School	.136	.066	.068	.041	*
ACADEMIC DISCIPLINE (Ref = Social Science)					
Engineering	-.459	.122	-.139	.000	***
Medical/ Health Sciences	.031	.049	.023	.535	
Physical Sciences	-.015	.036	-.016	.666	
Biological Sciences	-.011	.026	-.016	.665	
INSTITUTIONAL TYPE (Ref = Very High Research Activity)					
Type-High research activity	.047	.071	.019	.504	
Type – Doctoral/Research Univ	.046	.048	.029	.332	
Control *(Ref = Public)*	.021	.087	.008	.806	
Research Expenditures (Pctg.)					
Federal Government	.002	.006	.023	.777	
State Government	-.006	.007	-.039	.423	
Industry	.003	.007	.015	.712	
Institutional Funds	.005	.006	.051	.466	

	B	SEB	Beta	Sig.
(constant)	4.938	.708		.000
R^2	0.194			
Adjusted R^2	0.163			
Standard Error	1.028			
F	6.245			.000

Note: (N = 1,210; * p < .05, ** p < .01, *** p < .001)

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