Connections, Productivity and Funding:
An Examination of Factors Influencing
Scientists' Perspectives on the Market Orientation of Academic Research

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Dedication

To Ellie and Andy…
for the love and the levity.

To Mom and Dad…
for the roots and the wings.

And to Jay…
for always bringing the sunshine.

Abstract

This study examines scientists' perceptions of the environment in which they do their work. Specifically, this study examines how academic and professional factors such as research productivity, funding levels for science, connections to industry, type of academic appointment, and funding sources influence scientists' perceptions of the market orientation of science. The findings are based on data from a survey of 5,000 researchers (1,703 respondents) at 100 public research universities in the United States. The analyses demonstrate that connections to industry, certain types of scholarly productivity, opinions about the processes for obtaining funding, and service in a national advisory capacity are significantly related to scientists' perceptions of the market orientation of academic research.

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CHAPTER 1: INTRODUCTION

Partnerships involving universities and industry have been in existence much longer than many people may realize. In his seminal work *The Uses of the University*, first published in 1963, Clark Kerr described how “sometimes industry will reach into a university laboratory to extract the newest ideas almost before they are born. Instead of waiting outside the gates, agents are working the corridors” (p. 89-90). The Bayh-Dole Act, passed in 1980, gave legislative legitimacy to academy-industry partnerships and irrevocably altered their fundamental underpinnings (Lucas, 1994).

Experts cite a number of reasons why connections between university researchers and industry are particularly critical at this moment in history. For example, some authors reference the “intensification of [the] process, including the shortening of the time span between discovery and utilization, and increased reliance of industry on knowledge originated in academic institutions” (Etzkowitz, Webster, and Healy, 1998c, p. 2). Other researchers acknowledge that “the transformation of bio- and medical technology has produced a fusion of academic and industrial science,” (Geiger, 2004, p. 181) much stronger than in the past. The extent to which “universities have become significant agents of economic development…[and] now feel compelled to foster conditions for generating regional wealth,” (Geiger, 2004, p. 181) has also increased significantly.

The present study examines scientists’ perceptions of the state of current relationships between academic scientists and industry. Specifically, the research is driven by the question: How do scientists’ academic and professional experiences, including factors such as connections to industry, research productivity, perceptions of funding levels for science, appointment funding sources, and service experiences influence their perceptions of the market orientation of science?

Long a topic of conversation in academic circles, concerns about relationships between higher education and industry have intensified in public arenas. A 2008 *New York Times* article exposed Harvard child psychiatrist Dr. Joseph Biederman's failure to disclose $1.6 million in payments from drug companies over the course of a decade (Gardiner and Carey, 2008). A subsequent *Times* editorial (2008) called for the expansion of financial disclosure policies. Numerous local newspapers have run their own exposés on payments from pharmaceutical companies to physicians, most often focusing on physicians at university hospitals (Fauber, 2009; Tosto and Olson, 2008). Although a preponderance of attention is focused on physicians and industry, there are numerous academic professionals whose relationships with corporations are, according to the literature, cause for concern. A variety of studies, examined later in this paper (Blumenthal, et al., 1996a; Campbell, et al., 1998; Slaughter, et al., 2004; Campbell, et al. 2007a and 2007b), document threats to scientific integrity and public trust due to academy-industry connections involving faculty and administrators at almost every level of higher education institutions.

The timeliness of this topic is readily apparent, given recent actions by organizations such as the National Institutes of Health and the National Academies' Institute of Medicine. The former "has begun the formal process of writing regulations to govern how institutions ensure their researchers aren't biased by payments from outside companies" (Basken, 2009), while the latter has called for a ban on all gifts and material incentives given to faculty in the medical and health-care fields (Mangan, 2009a &

2009b). The American Medical Student Association (AMSA) has created an elaborate online scorecard designed "to assess the content of policies at medical schools throughout the country," in regard to "presence or absence of a policy regulating the interactions between their students and faculty and the pharmaceutical and device industries" (AMSA, 2009). Other organizations are working with politicians to bring about legislative change.

The Pew Charitable Trusts created The Prescription Project, one of whose aims is to facilitate the passage of the Physician Payment Sunshine Act, a bill that would require "drug, biologic, and medical device manufacturers to report certain gifts and payments ('transfers of value') made to physicians," (The Prescription Project, 2009).While partnerships between academic scientists and industry produce benefits to both, there are increasing concerns about the potentially detrimental impacts of these connections. Action is being taken in various sectors of the scientific community to address these concerns. Within science and without, constituents are demanding accountability, protection, and change.

Background

In regard to interactions between higher education and industry, market orientation is reflected in the steps institutions are taking to engage in academic capitalism. Institutions are not only "bring[ing] the corporate sector inside the university," but they are also "considering the institution as a marketer," (Slaughter & Rhoades, 2004, p. 1). The term "market orientation" encompasses a spectrum of behaviors engaged in by academics and their institutions. Increasingly, knowledge generated by faculty scholarship is no longer research just for the sake of research,

> "In this new economy, knowledge is a critical raw material to be mined and extracted from any unprotected site; patented, copyrighted, trademarked, or held as a trade secret; then sold to the marketplace for profit," (Slaughter & Rhoades, 2004, p. 4).

These types of actions have also been referred to as market or marketlike behaviors (Slaughter & Leslie, 1997) and include increasing competitiveness for funding and the various for-profit activities of universities.

There are many reasons why concerns about connections between academia and industry continue to grow in magnitude, becoming increasingly complex. Three primary explanations for the critical nature of this issue include: the changing nature of, and regard for, academy-industry relationships (AIRs) within higher education; influential factors external to academic science encouraging partnerships with industry; and rapid and extensive changes within certain disciplines, fostering environs for these types of partnerships.

Within research communities in higher education, general sentiment regarding academy-industry relationships has changed. Slaughter and Leslie argue that "a quiet revolution has already taken place. Analysis of financial data shows a shift from state block grants to grants and contracts that are targeted on commercial endeavor," (1997, p. 11-12). Recent literature presents both conceptual and empirical evidence that attitudes and policy climate have shifted toward viewing AIRs as valuable and necessary (for example: Good, 2004; Slaughter & Rhoades, 2004; Bok, 2003). While the transition has certainly been underway since the Bayh-Dole legislation of 1980, the impact and trajectories produced by this policy still astonish some commentators. Processing his experiences as president of the University of Michigan, Duderstadt wonders,

> "Perhaps the spirit of Bayh-Dole is not what should be driving university strategies for transferring the knowledge produced on their campuses to benefit the public but rather principles more consistent with the history of higher education in the United States and better aligned with the vision of the university as a place of unconstrained scholarship and learning," (Duderstadt, 2004, p. 58).

Though there is still considerable debate about the role of the market as it pertains to academic research, attitudes and norms pertaining to academy-industry connections have changed, and there is far less stigma associated with relationships between higher education and the corporate world (Krimsky, 2004; Slaughter & Rhoades, 2004).

In fact, cultural conversion within universities has transpired so dramatically that it is not uncommon to see components of academy-industry relationships represented in higher education as markers of current successes and targets for future goals. For example, departments increasingly rely on soft money from external sources to fund faculty members and their research, and these funding sources, more often than in the past, include national and international corporations (Campbell et al., 2007b; Slaughter & Rhoades, 2004; Campbell et al. 1998). Another example of shifting positions regarding these issues includes the practice of using connections to industry, such as patents applied for or received and start-up business participation, as factors in promotion and tenure decisions (Washburn, 2005; Holbrook & Dahl, 2004). These shifts in culture and practice are not happening merely at the level of the academic department. Institutions strive to equip themselves for the race to market by creating technology transfer offices and independent research facilities (Geiger, 2004; Slaughter & Rhoades, 2004), banking hope on the patent that might make them rich or wagering significant resources on windfalls from the increasingly for-profit climate of academic research (Washburn, 2005; Stein, 2004).

Yet another reason why connections between academia and industry continue to be a critical issue is that these relationships are often motivated by external factors, sometimes beyond the purview of researchers. For example, as state appropriations that once comprised larger portions of university budgets continue to shrink (Heller, 2006; Bok, 2003), partnerships between academic science and the for-profit sector become a means for survival. What began as a search for new funding sources, as previous support evaporated, has transformed into a full-scale partnership, with collaborators possessing not only more substantial resources but also distinct goals and objectives (Anderson, 2001). Although it would be a mischaracterization to suggest that academics previously disapproved of these relationships with industry, it is worth noting that not all faculty have embraced this rush to market (Kezar, 2004; Stein 2004; Slaughter & Rhoades, 2004).

Another example of external pressures shaping the scope of academic research is the growing focus many institutions place on being economic engines for their states or regions (Coleman, 2007; Kezar, 2004; Slaughter & Rhoades, 2004). Although this is not a new phenomenon, when coupled with the recent economic challenges of state and local economies, as well as aforementioned funding issues for higher education, these partnerships become increasingly critical components of financial sustainability. As universities labor to demonstrate their significance to immediate communities, connections with regional for-profit organizations play critical roles. The particularities of these partnerships, embraced by higher education as part of their public service missions, potentially influence the research directions of academic scientists (Washburn, 2005; Geiger, 2004; Slaughter & Rhoades, 2004).

A final factor contributing to the critical nature of academy-industry relationships is the evolution of certain disciplines and areas of technological growth (see, Washburn, 2005; Geiger, 2004; Rai, 2004; Kennedy, 2003). Due to the market relevance of the work coming out of certain fields, such as biotechnology and biomedical research, there are abundant, lucrative opportunities for academy-industry partnerships (Rai, 2004; Kennedy, 2003). Unfortunately, biomedical research presents some of the greatest opportunities for unprincipled conduct. Reports in both scholarly journals and the popular press have identified partnerships between universities and businesses in the biomedical arena that have produced conflicts of interest (Mangan, 2009a & 2009b; Rainy, 2006), ghost-authored papers (Ross et al., 2008), and questionable methodology in clinical trials of drugs (Cho & Bero, 1996). With such expansive growth in these particular areas and with so much at stake, academy-industry relationships are a particularly critical issue at this point in time.

As discussed later in the paper, science is changing, and so opportunities for connections between higher education and for-profit entities change as well. As the benefits and challenges of these partnerships come to light, discussion and debate will continue to surround the topic of academy-industry relationships.

Outline of the study

The literature review in Chapter 2 covers themes related to connections between the academy and industry, beginning with an examination of ways in which science is changing in terms of funding structures, the economy in general, and new types of science being undertaken. Then I look closely at published evidence of the impacts of market ideologies on academic research and the costs and benefits of a increasingly market-oriented system of scientific research. I then examine related ethical considerations. In regard to public confidence in academic science, the literature review also examines the impacts of scientific misconduct (or perceived misconduct) by researchers in higher education who work with partners in industry. Finally, I examine empirical data on the prevalence and impact of academy-industry relationships, with evidence that suggests cause for concern regarding the connections between academic research and commercialized science.

Chapter 3 presents the conceptual framework for the study, as well as the study's methodology. First, a conceptual overview of all variables is provided, and then a description and justification of the study's setting follows. The creation of the data collection instrument is described. The specific survey items that address issues of organizational justice, academic misconduct, and general perceptions of the environment for academic science are listed. Finally, the sample selection and data collection processes are described.

Chapter 4 presents the study's findings. Descriptive statistics, along with correlation and multiple regression techniques, were used to analyze the data. The chapter begins with descriptive statistics on all the variables. Means analyses are presented by various categories of respondents. Correlations are presented to show the direction and magnitude of relationships between all variables. Finally, regression analyses show associations between independent and dependent variables controlling for all other variables.

Chapter 5 summarizes the dissertation and answers the research question: How do scientists' academic and professional experiences, including research productivity, funding levels for science, connections to industry, type of academic appointment, and appointment funding sources, influence scientists' perceptions of the market orientation of science? Limitations of the study and directions for future research are also examined.

CHAPTER 2: REVIEW OF THE LITERATURE

Citizens of the United States have great faith in their institutions of higher education (Selingo, 2004). In fact, the confidence of the U.S. public in their colleges and universities often outpaces that of various branches of government and many religious institutions. This public confidence is, perhaps, the result of continuous adaptation by institutions of higher education to the societal needs of the citizens of the United States. Institutional responsiveness has also, however, contributed to the increasingly complex and multifaceted nature of universities in the United States (Kerr, 1982; Lucas, 1994). This transformation includes the development of relationships with for-profit organizations. Although the topic of increased market presence on university campuses has been part of institutional dialogue and collective consciousness for many decades, there appears to be a recent resurgence in the frequency and gravity of these conversations. Even the general public is beginning to have doubts about the focus of our nation's institutions of higher education (Kelderman, 2010). From concerns over the outsourcing of campus services to a decline in numbers of tenured faculty and a subsequent increase in more transitory employees, traditional campus cultures seem to be changing, yet again. Headlines in prominent journals read, "Industry and Academia in Transition," (Science, 2003), and "Is the university-industrial complex out of control?" (Nature, 2001), while bookshelves are crowded with titles such as, Shakespeare, Einstein, and the Bottom Line (Kirp, 2003), and Buying In or Selling Out? (Stein, 2004). Although there are, as these titles suggest, many areas of concern regarding the privatization and commercialization of academic institutions of higher education, perhaps nothing garners as much apprehension and controversy as the area of scientific research.

As universities look for additional and alternative funding sources, partnerships with industry become increasingly valuable in aspects both tangible and intangible. The promise of profit proves most alluring around the benches and in the laboratories of academic science. Whether one considers the potential impact of scientific research for the betterment of public life, or the financially lucrative connections to business, the possibilities seem endless. Yet, these ties between the work of university scientists and industry are not unfettered or without challenge. These partnerships have the potential to alter the longstanding, normative processes of academic science, as well as the resulting public goods provided to society at-large. Evidence suggests certain indiscretions are already taking place in regard to academic science and its relation to industry, causing concerns about the of erosion of public confidence in our nation's scientists and intuitions of higher education. What is relatively unknown, however, is the extent to which academic scientists share in the growing unease regarding academic-industrial partnerships. This paper focuses on the current environment for academic scientific research by examining the following progression of ideas: the extent to which science is changing**;** the extent to which market influence is reshaping commonly held notions of public good as it relates to science; and an interpretation of empirical research on academy-industry connections. The paper concludes with an examination of five empirical studies on university-industry relationships, as well as proposed directions for future research.

Academic Science in Transition

One need only peruse academic journals and prominent periodicals to see that the perception of and concern about change is stirring in scientific communities. These changes are met with open arms by some and with guarded skepticism by others. Some address the change of academic science with cries for rallying support of “non-instrumental science” (Ziman, 2003), while others explain the rationale and necessity of the new “Triple Helix model” (Etzkowitz, 2003). Scientists muse about the stability of science in the United States (Haseltine, 2007; Randall, 2007), and journalists express apprehension about the intersections of faith, government and the laboratory (Hall, 2007; Washburn, 2007). University presidents suggest that institutions “partner or perish” (Coleman, 2007), while editorials in academic journals ask when is enough, enough (*Nature*, 2001) and make lists of New Year’s resolutions to help get a handle on the relationship between science and society. No matter what side of the fence, champions and critics abound, but just what is it, exactly, that is garnering all the attention? What is going on in science?

Academic science is in transition: changing from what was once believed (albeit somewhat quixotically) to be pure, basic research, to a form of science where agendas are set with substantial influence from industries interested in marketing the innovations resulting from research and development. Scientific progress and economic development now go hand in hand. The magnitude of this change is extensive and undeniable. In some ways, however, these are not new phenomena, especially within the context of higher education in the United States. Academic science has been previously called upon to serve decidedly utilitarian aims, be it the industrial revolution at the turn of the twentieth century, or the industrial-military complex of the 1960s (Lucas, 1994; Rhodes, 2001). History repeats itself, reminding constituents that the basic creation of research institutions in the U.S.—as well as many of their significant progressions, such as the Morrill Act—were pragmatic and service-orientated (Lucas, 1994). Perhaps this new evolution is merely the next iteration in the changes of academic science. Leaders in the scientific research community, however, suggest that there are specific conditions that make the changes in academic science different this time around.

First and foremost, there are the changes and challenges surrounding the funding structures of scientific research. As academic institutions struggle with proportionally smaller appropriations from state and federal coffers (Heller, 2006; Bok, 2003; for example) scientists look for new ways to finance their research agendas. Industry is proving to be a willing partner: in 2009, industry funding to our nation's top research universities grew by 11.6 percent for a total of $3.2-billion (Brainard, 2010). In addition, efforts by the federal government to provide more funding have not always had the intended consequences. For example, the doubling of the budget of the National Institutes of Health at the turn of the twenty-first century resulted, in the eyes of some researchers, in a significant intensification of competition for already scarce resources (Martinson, 2007). Making the pot larger did not increase the size of the portions, only the number of ravenous consumers crowding around the table.

Changes in the structure of the economy have also changed the face of science. Slaughter and Leslie (1997), as well as Etzkowitz (2003) and his colleagues (Etzkowitz et al., 1998b) point to transitions in international economic competitiveness as one of the reasons science has recently shifted in such a dramatic fashion. In regard to the evolving global economy and impacts on higher education, one author points out that it was the

> "increased demand on industry's side, together with the decreases in the supply of federal funding [that] put marketlike pressures on faculty members and their institutions to shift focus in their pursuit of support for research" (Anderson, 2001, p. 231)

The global economy has many additional impacts for higher education (Bok, 2003), but this is one of the most significant.

Another important contribution to the changes in academic science, aptly tying in to the aforementioned arguments, has to do with the type of science being done. At the turn of the new century, Donald Kennedy—then editor of *Science*—stated, "Commercial interest in basic scientific work, especially in biomedicine, has exploded, and many companies are doing, in campus-like settings, research that was once done only in universities" (2000, p. 724). Changes in science due to revolutionary advances and unprecedented market potential are recognized by many authors as a significant factor contributing to the changing face of academic research (Washburn, 2005; Hall, 2004; Rai, 2004; Bok, 2003; Slaughter & Leslie, 1997). The commercial viability of academic science has never been greater. Institutions, as well as the individuals within them, are taking notice and taking action.

Finally, there is a sense among some principals in the area that this new realm of science mandates action, based on the societal implications of the possible results (Shapiro, 2005; Scott, 2003; Nichols & Weldon, 1997; Reiser & Bulger, 1997). For example, in an editorial highlighting the challenges and importance of public engagement by the scientific community, the Chief Executive Officer of the American Association for the Advancement of Science stated, “scientific advances are coming at an unprecedented pace, and they hold great promise for further improving the human condition” (Leshner, 2007, p.161). This sentiment is echoed by Kennedy:

> “Given the growing number of settings in which effective teams with new technologies can be focused on important research objectives, it is plainly time to take advantage of their capacity in the interest of public health. Significantly, both public science and proprietary science have moved closer to one another in what interests them and what they can do. Both sectors are performing basic research and doing it well. Both have access to technologies (many of them commercially developed) to support high-throughput biological analyses that would have been inconceivable a decade ago. So it may now be time to set aside our traditional skepticism about a national industrial policy and adopt a biomedical research strategy combining the creativity and individual skill of traditional publicly funded programs with the technology investment and team tradition of the commercial sector.” (2003, p. 1293)

Clearly, leaders in the world of science believe that not only are times different in the sense that interactions between the academy and industry are organizationally and fiscally logical, they are—quite possibly—morally imperative as well.

This discussion, as well as the Kennedy piece (2003), referenced above, not only suggest the consideration of interesting organizational transitions but also the proverbial “chicken and egg” conundrum: do universities look different because science looks different, or does science look different because universities look different? While it may be challenging to determine which came first, there is one certainty: things are different than they used to be. Academic science is changing.

Impacts of Market Influence on Public Good and Public Confidence

Another important consideration regarding connections between for-profit organizations and higher education is the extent to which market influence is reshaping commonly held notions of the public goods of public institutions. Traditionally, when one thinks of the public good of higher education, things like civic engagement, extension and outreach, sharing research with communities, arts and humanities, and coordination with other public organizations come to mind (Kezar, 2004; Gumport, 2000). To this end, there is a vast expanse of literature on the impact of the continued commercialization of higher education. From the outsourcing of campus services to the increased commercialization of academic research, the presence of market influences on university campuses is pervasive. There is particular contention surrounding the impacts of these market forces as they relate to scientific research. While examining these issues, authors, first and foremost, acknowledge both the costs and benefits of the current situation, with champions and critics sounding off of all sides of the general issue of the commercialization of higher education. In addition to the debate of the pros and cons of increasingly market-oriented academic research, literature focuses on the ethical considerations of this new paradigm. Finally, research demonstrates challenges to public confidence due to both perceived and actual wrong-doing by academic scientists working in concert with industry.

The Costs and Benefits of Market Influence

The commercialization of higher education, though certainly not an entirely new phenomenon, is occurring today at unprecedented rates. Although one could argue that there is nothing inherently problematic about this phenomenon, there is a wide array of questions being asked about this particular stage of the growth and development of higher education in the United States. What are the positive and negative impacts of the commercialization of higher education? What does the commercialization of higher education mean in regard to public good and the needs of the citizenry? A variety of perspectives is available for consideration.

The benefits of commercialization have been ripe for assisting in changing, challenging times. In an era when state and federal support for higher education is trending downward, in regard to the overall percentage of an institution's budget (Heller, 2006), colleges and universities are looking for innovative ways to make ends meet and achieve all of their goals and commitments. Increasing competitiveness among colleges and universities has also led to an institutional arms race, with each campus looking to out-reach its peers (Bok, 2003). Campus leaders and their constituents have seen the myriad of means by which commercialization can bolster slowing appropriations and help achieve dreams of dominance. Institutions also look to the commercialization of particular areas and services in order to operate more efficiently. Auxiliary functions including, but not limited to, food service, bookstores, residence halls and custodial services are often out-sourced to other organizations specializing in the work (Priest, Jacobs & Boon, 2006).

Ultimately, no matter the stated reason, most proclaimed benefits regarding the commercialization of higher education have to do with money. When speaking in support of these changes, authors talk about ideas such as the creation of new, creative sources of revenue (e.g. Hearn, 2006; Bok, 2004; Slaughter & Leslie, 1997) and the formation of jobs, businesses, and economic clusters (e.g. Bok, 2004; Geiger, 2004; Good, 2004; Rhodes, 2001; Slaughter & Leslie, 1997). Increases in institutional prestige, external connections to industry and overall enhancement of research enterprises are also seen as benefits of the increasingly market-focused perspectives of academic institutions (Slaughter & Leslie, 1997). Much of the aforementioned economic growth is the specific result of the Bayh-Dole Act of 1980, the intentions of which were to encourage technology transfer by moving the ideas generated by universities into the broader economy by reducing the bureaucracy of licensing (Washburn, 2005; Geiger, 2004; Bok, 2003; Etzkowitz & Stevens, 1998). Relationships with industry, fostered in order to transfer technology to the public sector and take advantage of the resulting royalties and profits, prove very lucrative for a great many institutions, departments and individual faculty members.

Although there are certainly undeniable benefits obtained from commercial activities of higher education institutions, critics are much more vocal about the detrimental effects. When examining the challenges and costs of the increasingly entrepreneurial focus of higher education, authors, first and foremost, lament what is seen as a pervasive assault on traditional values of colleges and universities in the U.S. As Bok (2004) says,

> "the costs are, if anything, more speculative and intangible than the rewards. Seldom, if ever, can they be expressed in terms of money. More often, they have to do with the elusive world of values—specifically, with the principles that define the proper conduct of academic pursuits and thereby enhance their quality and meaning." (p. 36)

Authors argue that the distinctive factors setting academic institutions uniquely apart from business are indeed the very characteristics being tested and eroded by the intensification of commercialization (Chambers, 2005; Washburn, 2005; Bok, 2004; Geiger, 2004; Hall, 2004; Krimsky, 2004; Slaughter & Rhoades, 2004; Stein, 2004). Slaughter and Leslie (1997) suggest that in many areas of the academy, there has been a complete "encroachment of the profit motive into the academy" (p. 9). Specifically, authors are concerned about issues involving faculty productivity (Washburn, 2005; Bok, 2004; Slaughter & Rhoades, 2004; Stein, 2004), equitable division of resources throughout institutions and a lack of focus on the arts and social science (Bok, 2004; Geiger, 2004; Stein, 2004), impacts on student learning (Washburn, 2005, Slaughter & Rhoades, 2004), graduate student training and mentoring (Washburn, 2005; Slaughter & Rhoades, 2004), and the processes of academic science (which will receive much more attention later in the paper) (Bok, 2004; Duderstadt, 2004; Hall, 2004; Krimsky, 2004; Slaughter & Rhoades, 2004; Stein, 2004). A closer examination of the aforementioned concerns provides a clearer understanding of the erosion of values of higher education.

Consider the impact of marketization on the work of faculty. Multiple contributors to Stein's (2004) work on the impacts of commercialization of higher education, as well as many others (Priest & St. John, 2006; Washburn, 2005; Geiger, 2004; Slaughter & Rhoades, 2004; *Nature*, 2001; Slaughter & Leslie, 1997) list the following issues related to faculty work as particularly salient:

- Shifts in research agendas to those that are financially profitable;
- Chasms in the procurement and distribution of resources between departments with commercially viable research (and teaching products) and those without;
- Differences in hiring considerations, as well as the evaluation of promotion and tenure, when commercial success enters into the equation;
- Impacts on teaching and student learning, training and mentoring as faculty (and institutional) foci become increasingly entrepreneurial;
- Deterioration of research ethics in regard to sharing, competition, conflicts of interest; and the integrity of research design, methodology and data analysis.

Many of the challenges to the traditional values of higher education manifest themselves with a simple examination of the work of the faculty.

Another concern, as academic institutions spend more time pursuing commercially tenable outcomes, is the abandonment of more traditional notions of public good. This is particularly true of public research institutions, though could easily apply to all traditional institutions of higher education. As institutions dedicate more and more time to entrepreneurial ventures, what public needs are ignored (St. John, 2006; Chambers, 2005; Kezar, 2005; Washburn, 2005; Geiger, 2004; Hall, 2004; Krimsky, 2004; Stein, 2004; Slaughter & Leslie, 1997)? Institutional conflict of commitment is noted by these authors as a serious challenge in the changing world of a more commercially-focused academia.

Perhaps one of the most disconcerting realizations about the myopic focus on commercialization is the remote likelihood that an institutional discovery will bring vast external resources (Washburn, 2005; Bok, 2004; Duderstadt, 2004; Good, 2004; Stein, 2004). For all the rush to establish institutional patenting processes and set forth the wheels of commercial productivity, it is well known (though perhaps not readily acknowledged) that financial windfalls such as Gatorade (for the University of Florida) are not the norm. While there is certainly money to be made from royalties on patents and connections with business over time, the idea that institutions will apply for patents and instantly see large commercial results is certainly misleading.

While, as demonstrated above, there are any number of dimensions on which to assess the merits and drawbacks of the privatization of academia. In perhaps one of the more comprehensive analyses of the time, Adrianna Kezar (2004) reviews a wide array of empirical literature on the impacts of the privatization of various facets of higher education, including administration and management, academic research, faculty, curricula and athletics. Upon establishing the prevalence of industrial behaviors in each of these areas, Kezar goes on to summarize the articles' findings regarding effects of these types of relationships and modes of practice. Although anecdotal claims are often made regarding the benefits of more market-driven academic performance, empirical evidence demonstrates otherwise. As Kezar concludes in the article, costs frequently outweigh benefits:

> "More and more, the public good is being aligned with key features of [the industrial model] as opposed to […] collective benefits for society as a whole. Likewise, the charter has moved from public investment and an interrelationship

> to incentives to privatize, marketize, and a less mutual or interconnected relationship between higher education and society. Institutional goals are becoming more aligned with individual consumers rather than societal goals," (p. 450).

Ultimately, when summarizing empirical evidence regarding the industrial model's effects on public higher education, Kezar states, "clearly, little evidence to date supports the benefits of this model" (p. 450), and that "the costs outweigh the existing unknown benefits" (p. 452).

Geiger (2004) reaches a similar hypothesis, concluding that although marketization has contributed "greater resources, better students, a far larger capacity for advancing knowledge, and a more productive role in the U.S. economy" (p. 265) to our nation's universities, it has also brought pronounced inequity and increased hierarchy among institutions. Geiger argues that institutions have sacrificed independence, as well as their mission to the public, all while increasing the possibility and probability of conflict of interest and conflict of commitment. While Geiger does not condemn institutional connections to the market, he does issue strong admonitions for the future of these partnerships.

Although, as demonstrated above, there are a variety of ways in which the industrial model impacts the daily workings of higher education, this paper will continue to focus on the connections between academic scientific research and for-profit organizations.

New Ethical Considerations for the Market-Oriented Paradigm

Not only has market-influenced scientific research provided a wide array of costs and benefits to be debated and discussed, it has also given rise to new dialogue in the realm of scientific ethics. Some authors believe that the production of this new type of research is brings forth its own series of ethical considerations.

On the most basic, theoretical level, are there differences between industry and academic institutions that require their own set of ethical standards? For example, Spier (1998) asks “whether the different mission statements or *modi operandi* of the university *vis à vis* industry throws up additional ethical issues?” (p. 375). Spier contrasts the goals and purposes of these two types of institutions and suggests that the inherent differences between them will have consequences for any partnerships that may emerge. Although he does not imply that academy-industry relationships are inherently flawed, Spier does suggest that due to the individual characteristics of these institutions, relationships will require extra vigilance. In another essay, Spier (1995) cautions “when there are imbalances or different views of the objectives of the interaction, then it can be expected that problems will arise” (p. 157). As referenced earlier in this paper, Scott (2003) reminds readers that the production of knowledge is changing and the “once-clear boundaries between the great systems of modernity—the State, the market, culture and science—are being rapidly eroded” (p. 81). Shapiro (2005), meanwhile, suggests that the “unprecedented success of the scientific enterprise” gives rise to the “inevitable discourse that will arise on how to give our new knowledge its moral resonance and greatest meaning,” (p. 121). Clearly, such changes will require renewed attention and commitment to ethical standards.

In addition to the aforementioned principally philosophical calls for ethical shifts based on the increasing market influence on scientific research, various authors have provided analysis and investigation concerning this same idea. In a recent paper, research ethicist Kenneth Pimple provides “a simple yet comprehensive organizing scheme for the responsible conduct of research” (2002, p. 191). The following categories are included in his heuristic: (1) scientific integrity, (2) collegiality, (3) protection of human subjects, (4) animal welfare, (5) institutional integrity, and (6) social responsibility (p. 193-4). Of particular interest are many of the subcategories included within the broader themes of institutional integrity (5) and social responsibility (6): conflict of interest, conflict of commitment, institutional oversight, and institutional demands and support (institutional integrity); and research priorities, public service, public education, and advocacy by researchers (social responsibility). In fact, in response to Pimple’s article, Slaughter (2002) states that the inclusion of categories such as institutional integrity and social responsibility are

> “particularly useful [because these] domains […] capture important areas of ethics not usually included in governmental (Public Health Service, National Science Foundation, Office of Science and Technology Policy) and science (Committee on Science, Engineering, and Public Policy of the US National Academy of Sciences) association treatments” (p. 219).

Similar findings in an empirical study confirm the weight of concepts such as institutional integrity and social responsibility in the ethical paradigms of modern science. A typology created by Kelley and Chang (2007) documents ethical failures by institutions of higher education. This study categorizes wrong-doing as either minor or serious failures, and as either individual or organizational failures. Results of this study classified “manipulating research results” and “inappropriate ties to business” (p. 418) as severe in the seriousness of failure category. Authors also provided rationale for the severity of the failure assessment, including:

“manipulating research results: societal/medical action may be taken that can damage others irreversibly,” and “Inappropriate ties to business can result in departments providing ‘results’ that satisfy a business but are false, thus having long term negative societal impacts” (p. 418).

Current research thus provides examples of how those who think about modern research ethics are taking new concerns related to market influence into serious consideration.

While this call to revisit ethical standards of research may appear radical in some areas of academe, within the context of health care, the necessity seems clear. Recent literature provides examples to this effect. In summarizing results on the prevalence of academy-industry relations in medical schools and teaching hospitals, Campbell states, “Failure to address the existence and influence of industry relationships with academic institutions could endanger the trust of the public in US medical schools and teaching hospitals” (2007b, p. 1786). Taking this notion a step further, editors of the Journal of the American Medical Association issued a strongly worded call for new ethical standards in regard to authorship guidelines, disclosure of conflicts of interest, and oversight of data analysis (DeAngelis & Fontanarosa, 2008). The authors concluded their recommendations by saying,

> “When integrity in medical science or practice is impugned or threatened—such as by influence of industry—patients, clinicians, and researchers are all at risk for

> harm, and public trust in research is jeopardized. Ensuring, maintaining, and strengthening the integrity of medical science must be a priority for everyone" (p. 1835).

As demonstrated in the next section, consideration of the aforementioned ethical standards is significant, given the propensity for perception of wrong-doing—be it imagined or actual—when industry is involved in scientific research.

The Influence of Markets on Misbehavior and Misconduct: Perceived vs. Actual Wrong-Doing

When it comes to relationships between industry and the academy, the timeless adage "perception is everything" proves especially compelling. Simple perusal of news stories related to university-industry relationships could be cause, gratuitous or legitimate, for alarm. In fact, one author suggests, "As the press produces more articles and new stories about connections between universities and business or industry, the perception that these alliances are problematic intensifies," (Anderson, 2001, p. 226). This assertion is supported by newspaper headlines and peer-reviewed research, alike. For every story such as the one regarding investigations into connections between pharmaceutical companies and doctors who worked on the *Diagnostic and Statistical Manual of Mental Disorders* (Rainey, 2006), there is another concerning federal and institutional legislation introduced to expose and curtail physician-industry relationships (Campbell, 2007).

It appears that the public has a right to be concerned about relationships between for-profit business and institutions of higher education; and if the public is concerned, then scientists should be apprehensive as well. Mistrust of science by the citizenry can be cause for alarm in academic communities as, "even the appearance of conflict of interest may undermine the public's trust in university scientists" (Kodish et al., 1996, p. 1287). Researchers actively engaged in the study of academy-industry relationships, in addition to providing empirical evidence suggesting—at the very least—procedural complexities of academic relationships with for-profit organizations, issue cautionary edicts on problems of public perception. In 1996, Blumenthal wrote,

> "As a final and perhaps most elusive consideration in weighing the consequences of AIRRs, the effects of these relationships on the public's perceptions of science and scientists must be taken into account. Here, we tread on very slippery ground from an empirical standpoint. Public trust in academic life sciences is critical for continued government investment in the life sciences. However, it is difficult to gauge how AIRRs will affect that level of public trust." (p. 1295)

Conflict-of-interest policies thus have become a common theme in the discussion of public confidence, science, and industry.

The obvious response to perceived public discontent and skepticism: increased policy surrounding academy-industry relationships. Perception tends to breed policy. Frankel (1996), in a discussion of the complex truths and fictions surrounding relationships between academy and industry, states that,

> "Public policy responds to perception and appearance as much as it does to reality, and the values and norms that shape expectations and influence perceptions are central to our understanding of conflict in the policy arena," (p. 1298).

Frankel goes on to suggest that the “content [of policies] perform important symbolic functions in addition to whatever concrete impact the policies might have on a situation.” (p. 1302). The establishment of conflict-of-interest policies at both the institutional and federal level becomes an important step in responding to perceived misbehavior by academic scientists.

Although policy implementation may—to a certain extent—assuage public concern, it is not a silver bullet in regard to actual effectiveness. In fact, a recent report from the Inspector General of the Department of Health and Human Services (Levinson, 2008) asserts systemic failure by the National Institutes of Health (NIH) to oversee financial conflicts of interest by academic researchers and calls for “a more active role in overseeing financial conflicts of interest among grantee institutions” (p.iii). Three major findings in the report included: 1) the inability of NIH to “provide an accurate count of the financial conflict-of-interest reports that it received from grantees” (p. ii); 2) a lack of awareness by NIH “of the types of financial conflicts of interest that exist within grantee institutions” (p. ii) due to lack of information in generated reports; and 3) the reliance of NIH on the “good faith of grantee institutions to ensure compliance with Federal […] regulations” (p. iii) rather than issuing direct oversight. Although NIH officials responded to the report by stating that existing regulations are sufficient, bioethicist Jeffrey P. Kahn disagrees: “[the NIH] has no evidence to support their assertion that things are working fine” (Brainard, 2008). Recent research supports this assertion, suggesting that current regulations relating to conflict-of-interest policies are insufficient, the temptations and pressures from industry are real (Dana & Lowenstein, 2003), and the need for disinterested research persists (Elliott, 2008).

Although perceptions of wrong-doing and conflicts of interest by scientists may give rise to hesitation and unease, actual misconduct can be flat-out destructive to public confidence in academic research. Scandals involving scientific research damage the public's collective confidence in the work of scientists. Cases like the Huang stem cell disgrace (Brender, 2006) and the continuing saga of the Purdue fusion researcher (Monastersky, 2008), continue to erode public trust. Evidence of ethical lapses and unscrupulous science are particularly disheartening when these are due to connections with industry. One recent example of industry involvement in disreputable science is the Bero et al. (2007) study demonstrating that randomized controlled trials of drugs designed to elicit similar results "are more likely to report results and conclusions favoring the sponsor's product" (p. 1001). In another case, Ross et al. (2008) demonstrate the prevalence of guest-authored and ghostwritten papers produced in conjunction with, pharmaceutical giant, Merck's clinical trials. Bero (2007) confirms earlier findings by Cho and Bero (1996) that "[journal] articles with drug company support are more likely than articles without drug company support to have outcomes favoring the drug of interest" (p. 485), and demonstrates the trend of unseemly influence by drug companies continuing to manipulate academic science. Such research results do little to assuage public concerns about relationships between academia and industry.

Recent research also suggests that the atmosphere in which academic science takes place is becoming fraught with more tension and stress. It is thought that these conditions of strain can lead to scientific misconduct. A 2006 paper by De Vries et al. describes normal misbehavior among scientific researchers as "common, everyday problems [that] fall into four categories: (1) the meaning of data, (2) the rules of science,

(3) life with colleagues, and (4) the pressures of production in science" (p. 44). While the paper does not condone unethical research practices of any sort, it does explain that "more mundane (and more common) transgressions [are linked to] the ambiguities and everyday demands of scientific research" (p. 48). The authors also caution that "social conditions [of science] lead to both acceptable and unacceptable" (p. 49) research practices. Further evidence suggests that scientists view the fields in which they do their work as increasingly competitive, and that the competition seldom yields positive effects on their research (Anderson, et al., 2007a). Finally, an examination of the traditional Mertonian norms (Merton, 1942) of science, compared to the counternormative principles of these established standards, demonstrates that scientists experience significant levels of dissonance between their own subscription to the norms of science and their perceptions of the normative interpretations of their colleagues (Anderson, et al., 2007b). The authors suggest that the "high levels of normative dissonance […] represent a stress on scientists and on the organizational systems that support scientific research," and that such stress can create "persistent tensions in the scientific environment" (p. 12). These examples of tension and strain help us understand the context in which misconduct often occurs.

Although there is not a great deal of empirical evidence suggesting that connections with industry directly lead to scientific misconduct, there are data demonstrating potential breaches of research ethics. In one particular example, Martinson et al. (2005) conducted a study where scientists were asked to report on their own misbehavior and misconduct. In this study, among other reported transgressions, almost 16 percent of scientists admitted to "changing the design, methodology or results of a study in response to pressure from a funding source" (p. 737). Due to the design of this study, there is no actual way to know which funding sources exhibited pressure, but given the prevalence of academy-industry relationships (Campbell et al. 2007a; Campbell et al. 2007b), it is possible, if not probable, that at least some of the aforementioned influence came from industry sources. This hypothesis is supported by qualitative data from a related study on the bending of rules by scientific researchers (Ronning et al., 2007). In focus group conversations, scientists talked at length about how pressures from funding sources encouraged rule bending that ranged from subtle to flagrant. Participants commented on how while working with pharmaceutical companies it was "amazing to watch how they adjust the scientific method" (p. 16) to meet their own needs. Scientists also shared examples of industry representatives asking "can you make the data show this?" (p. 16). The paper goes on to assert that while there are no data to prove that "funding organizations are explicitly demanding that scientists break rules or engage in misconduct, there is evidence that rules are being bent with silent blessings from the powers that be" (p. 16). While there is no conclusive evidence to show intentional misconduct by industry, scientists involved in these relationships admit to feeling pressured, just the same.

The aforementioned Martinson et al. study (2005) also reinforces an important point concerning the impact of misbehavior and misconduct in science. While much public and institutional attention toward research misconduct focuses on extravagant transgressions such as fabrication, falsification and plagiarism (FFP), Martinson and colleagues demonstrate that there is "a range of behaviors extending far beyond [FFP]" (p. 737). These behaviors—which include actions such as publishing the same data in more than one publication, overlooking others' use of flawed data, withholding details of methodology or results, and using inadequate research design—are far more common. The authors go on to suggest that this range of misbehaviors, "may have unexpected and potentially detrimental effects on the ethical dimensions of scientists' work" (p. 738). This concern is shared by other academics studying scientific misconduct and the changing face of scientific research. Drummond Rennie's reference to the "little murders" (Beauregard, p. 185) of science provides an important new description for reconsidering the behaviors and mindsets that are truly damaging the integrity of science. This idea is echoed by Zigmond and Fischer, who state "we believe it is the misdemeanors of research with which scientists struggle most often" (2002, p. 230). The authors go on to suggest that these "misdemeanors may gradually inflict the greatest harm to the scientific community" (p. 231). As industry continues to exert influence upon the work of scientists, attention must be paid to the "little murders" taking place in the scientific environment.

Although there are many benefits to the myriad of connections between university scientists and for-profit organizations, there is considerable evidence suggesting that these same relationships may undermine and erode notions of public good and public confidence in scientific research. It is important to understand the tensions in these relationships, as well as the resulting consequences of this stress.

Academy-Industry Relationships: A Closer Look

When discussing academy-industry relationships (AIRs), or the increasing privatization of academic research, it is critical to gain a more exact understanding of exactly what these connections entail. The following section addresses the definition, prevalence, benefits and challenges of relationships between academic and industrial science.

The definitions of academy-industry relationships prove expansive enough to include and account for the multifaceted nature of these interactions. According to Anderson (2001),

> "In a general sense, they involve an exchange of resources, ideas, or influence between some unit within a university (possibly even an individual) and some for pro-fit entity or subunit thereof" (p. 227).

Connections can be between institutions—such as the University of California – Berkeley and Norvartis—or they can be between departments or individual faculty members and a corporation. Anderson also states that when considering AIRs, the focus should really be on multiple institutions and relationships (not just one), and the increasing trend of what Slaughter and Leslie (1997) would call academic capitalism: the "institutional and professorial market or marketlike efforts to secure external moneys" (p. 8). This larger scope takes into account the full range of market and marketlike behaviors in which faculty, departments, and institutions engage (Slaughter & Leslie, 1997). According to Slaughter and Leslie (1997), these behaviors include activities such as: increased competition for funding from a wide range of sources, partnerships with industry, formation of and investment in start-up companies, and increased patenting activities and resulting royalties and licensing.

Empirical research provides even clearer definitions of academy-industry relationships. When asking survey participants or interviewees to comment on their personal relationships with industry, the definitions become more specific. In the empirical research that follows (Campbell et al. 2007a, 2007b, 1998; Slaughter et al., 2004; Blumenthal et al., 1996a, 1996b) connections with private, for-profit organizations include:

- faculty members' personal relationships as consultants, executives, or members of speakers bureaus or boards of directors;
- faculty members' personal receipt of biomaterials, equipment, gifts, or money;
- institutional/departmental funding in the form of fellowships, discretionary funds, or sponsorship of training and continuing education;
- institutional/departmental receipt of biomaterials, equipment, drug samples or gifts.

Although there are certainly other possibilities for and characterizations of these relationships, the aforementioned connections are predominantly featured when referring to academy-industry relationships. When defining academy-industry relationships, researchers also take into account the tangible results of interactions between scientists and corporations. The patents, royalties, marketable products, and start-up companies resulting from academic partnerships with industry all contribute to the complexity of these relationships.

Not only, as demonstrated above, are there a wide range of interactions that fall under the definition of academy-industry relationships, there is incredible professional proliferation of these connections throughout various facets of higher education. Researchers interested in understanding the size of scope of relationships between academic and industrial science have provided considerable evidence substantiating their prevalence. Faculty members in all reaches of our academic institutions—in clinical and non-clinical settings, performing basic and applied research—report relationships with industry (Campbell, et al., 2007a, 2007b, 1998; Boyd and Bero, 2000; Wazana, 2000; Blumenthal et al., 1996a and1996b). In addition to all of the practicing scientists, engineers and physicians, these relationships extend to areas of institutional administration, including 60 percent of department chairs (Campbell et al., 2007b) and 36 percent of members of institutional review boards (Campbell et al., 2006).

Closer, empirical observation of the relationships between universities and corporations allows understanding of the impacts of these connections, including analysis of costs and benefits. According to the research, resulting positive outcomes of AIRs include: additional funding sources for many faculty, departments and institutions (Campbell, 2007b; Slaughter et al., 2004; Blumenthal et al., 1996a, 1996b); opportunities for commercial application of the science and commercial productivity by the researcher (Bok, 2004; Etzkowitz, 2004; Slaughter et al., 2004; Campbell et al., 1998; Slaughter & Leslie, 1997;); institutional prestige (Slaughter & Leslie, 1997); certain levels of increased academic productivity (Blumenthal et al., 1996a); increased awareness of various possibilities for medical treatments (Wazana, 2000; increased understanding of benefits, standards and procedures for relationships with industry (Campbell et al., 2006; Etzkowitz, 2004; Slaughter & Rhoades, 2004; Slaughter et al., 2004); and a general ability to recognize the practical needs of society (Prigge, 2005). While there may not be universal agreement on the extent to which these results are positive, many of the aforementioned concepts are largely considered to be benefits of relationships between institutions of higher education and industry.

Costs—or even decidedly detrimental results—rather than benefits are more commonly reported in research on the impacts of relationships between universities and corporations. Empirical evidence justifies many speculative concerns regarding these relationships. Examples of the negative effects of AIRs include: increasing secrecy and withholding of information (Slaughter et al., 2004; Bekelman et al., 2003; Campbell et al., 1998; Blumenthal et al., 1996a and 1996b); increasing focus on commercially tenable projects and less interest in basic research (Slaughter et al., 2004; Campbell et al., 1998; Blumenthal, 1996a and 1996b); declining levels of academic productivity due to certain levels of interaction with industry (Blumenthal, 1996b); opportunities for conflict of interest increasing and perception of personal conflict of interest remaining low (Campbell et al., 2007b; Campbell, 2006; Slaughter et al., 2004; Wazana, 2000); research funded by industry tending to produce results favoring the sponsor (Bero et al., 2007; Bekelman et al., 2003; Cho & Bero, 1996); repeated contact with pharmaceutical representatives influencing prescription practices of physicians even when there is no known difference in the effectiveness of comparable drugs (Wazana, 2000).

While many of the aforementioned empirical articles suggesting negative impacts of AIRs are the results of individual studies, two of the cited works are systematic reviews and meta-analyses of multiple articles. Work by Bekelman, Li and Gross (2003) and Wazana (2000) examine 37 and 29 peer-reviewed articles respectively, and the conclusions of each demonstrate that there appear—empirically—to be far more costs to AIRs than there are benefits. Further examination of key empirical studies provides a more thorough understanding of the nature of academy-industry relationships.

Empirical Research

In the section that follows, five empirical studies are examined. Each study expounds upon the frequency and impact of university-industry relationships. While theoretical literature on academy-industry relationships is widespread, empirical evidence operationalizing and quantifying these relationships is increasingly necessary. As policy makers at institutional, state and federal levels consider policies regarding issues of disclosure and conflict of interest, it is important to have a descriptive, quantifiable sense of the challenges stemming from academy-industry relationships. The five articles that follow provide measureable definitions and scope for understanding the breadth and depth of the impacts of relationships between higher education and business. Critics of AIRs have offered speculation and theory. The work that follows gives empirical validation to these concerns.

Blumenthal et al. (1996a) present a compelling quantitative portrait of the influence of industry relationships on life-science faculty, while Campbell and colleagues (1998) examine the frequency and impact of corporate gifts to academic life scientists. The 2004 Slaughter, Archerd and Campbell article provides a qualitative analysis of how faculty members negotiate relationship boundaries with industry. Campbell's research team provides two additional studies that capture and quantify the industry connections of academic department chairs (JAMA, 2007b) and physicians (NEJM, 2007a).

The Productivity of Researchers with Industry Relationships: Blumenthal, D., Campbell, E. G., Causino, N., and Louis, K. S. (1996a). Participation of Life-Science Faculty in Research Relationships with Industry. *The New England Journal of Medicine, 335*(23), 1734-1739.

Blumenthal, Campbell, Causino and Louis (1996a) examined the manner and extent to which relationships with industry affected the academic productivity of scientific researchers. This study sought to understand the "prevalence and magnitude of industrial research support" (p. 1736) and its relationship with: (1) the academic activities, (2) commercial activities, (3) restrictions on communication and effect on choice of research, and (4) changes in extent and effects of industrial research support (Blumenthal et al., 1996a). The researchers surveyed 3169 faculty members in the life, chemical and engineering sciences. A total of 2052 participants completed the survey, for a response rate of 65 percent.

Results of the study demonstrated that, in 1996, 28 percent of participants received industry funding for their research activities. There was a significant difference ($p<0.001$) between the support received by clinical and non-clinical scientists, at 36 and 21 percent respectively. This support comprised almost 9 percent of all total research support, and again, was significantly different ($P<0.001$) for clinical compared to non-clinical researchers, at 11.9 and 6.4 percent respectively.

Analyses demonstrated that there was, overall, increased productivity and participation for participants with industrial funding. These researchers published more articles and provided more service to their universities and fields of study than their peers without funding from industry. An interesting finding regarding levels of productivity, when analyzed as a proportion of a total research budget, is that as the overall proportion of industry funding increased, the productivity of the researcher decreased. For example, “rates of publication, numbers of service activities, and publication-influence scores were highest for faculty members with minimal or moderate support from industry (one third or less of the person’s total research budget),” (p. 1736). Faculty members with higher proportions of industry support were found to be less productive. In fact, researchers with the highest levels of financial support from industry had significantly lower rates of publication than their peers with less support.

In regard to commercial activities, Blumenthal et al. discovered that—not surprisingly—life-sciences researchers with industry funding were more likely to “report that their research had some commercial outcome,” and that “both the frequency of commercial outcome and their stage of advancement increased with the level of industrial support but peaked at an intermediate level (34 to 66 percent),” (p. 1737). Scientists with industry funding were also more likely to report “restrictions on their communication,” and “that they had refused requests from other academic scientists to share research results or biomaterials,” (p. 1737). These same scientists also indicated that their research agendas had been influenced by the “likelihood that their results would have a commercial implication,” (p. 1737).

Overall, the study demonstrates costs and benefits to involvement with industry sponsors. While researchers with industry funding may end up being somewhat more productive and commercially successful, these same scientists are also “twice as likely to engage in trade secrecy or to withhold research results from colleagues as are investigators without such support” (p. 1738). This same commercial success may also be inhibiting the pursuit of more basic research, in favor of more lucrative commercial endeavors. Finally, there are limits to the productivity benefits of industry funding, as researchers receiving more than two thirds of their support from for-profit organizations tend to be less productive that those with lower levels of funding.

The Impact and Importance of Corporate Gifts: Campbell, E. G., Louis, K. S., and Blumenthal, D. (1998). Looking a Gift Horse in the Mouth: Corporate Gifts Supporting Life Sciences Research. *Journal of the American Medical Association, 279*(13), 995-999.

Campbell, Louis and Blumenthal (1998) conducted a study regarding the impact of corporate gifts on the work of academic life scientists. The researchers asked the following questions: “(1) How prevalent in major universities are research-related gifts? (2) How important are these gifts to faculty members’ research? (3) What characteristics exemplify faculty who are likely to receive research-related gifts? (4) What, if anything, do donors expect in return for a research gift?” (p. 995). Of the 3394 surveyed life science researchers, 2167, or 64 percent, responded. Campbell et al. defined gifts as, “lab equipment, biomaterials, discretionary funds, support for students, and trips to professional meetings” (p. 996). Respondents were asked to identify how important, on a five-point scale, these gifts were to their research progress.

Results of this study demonstrate that “43 percent of respondents (920 faculty) received a gift from industry (independent of a grant or contract) to support their research” (p. 996). Twenty-four percent received biomaterials, 15 percent received discretionary funds, 11 percent received equipment, 11 percent received trips to professional meetings, and 9 percent received support for students. The frequency of this receipt of gifts was split almost evenly between single gifts and multiple gifts from industry to life science faculty members.

Although the value of the gifts varied by type, faculty members receiving the corporate gifts viewed many of these contributions as anywhere from important to essential to the work being done in their labs. For example, 75 percent of scientists who received only biomaterials evaluated these gifts as “essential,” “very important,” or “important.” (p. 997). The same can be said for “66 percent of those who received only discretionary funds, and 67 percent of those who received only research equipment (P,0.001)” (p. 997). Scientists who received gifts were also more productive in regard to publications in peer-reviewed journals, hours of student contact, and involvement in institutional service activities. These results hold even across a variety of control variables, such as sex, academic rank, and funding levels. These same scientists were also significantly more productive in the “commercial outcomes of research ranging from the most preliminary (applying for a patent) to the most commercially advanced (such as having a product on the market or a start-up company)” (p. 997).

Corporate donors did not, in the eyes of the scientists who received these contributions, give these gifts for free. For example, donors expected (among other things) acknowledgement in publications, the use of gifts for agreed upon purposes, prepublication review, future consultation by the scientist receiving the gift, and ownership of all patentable materials resulting from the gift (p. 997). Thus, although gifts allow scientists more productivity and enable research that was previously not possible, gifts come with strings—some more binding that others. Restrictions placed on some of the gifts challenge the very ethics and norms that govern the work of scientists. For example, this study demonstrates that traditional patterns of behavior among scientists are being disrupted by clauses restricting the sharing biomaterials given as gifts. The relationships between gift givers and recipients also become increasingly problematic when they are used as a means to circumvent "institutional administrative structures designed to manage academic-industry research relationships" (p. 999). Clearly, corporate gifts are a double-edged sword for scientific researchers. The authors conclude by stressing the importance of awareness regarding "institutional policies that govern gifts vs. grants and contracts" (p. 999). They also suggest that current institutional policies should be revised to protect the interests of both productive academics and industrial donors.

Living in Both Worlds: Slaughter, S., Archerd, C. J., & Campbell, T. I. D. (2004). Boundaries and Quandaries: How Professors Negotiate Market Relations. *Review of Higher Education*, *28*(1), 129-165.

In this qualitative inquiry, Slaughter, Archerd and Campbell (2004) investigated how academic researchers negotiated boundaries between their work as scientists and the work they were doing with industry. Specifically, the authors addressed four main questions in regard to the academic work scientists perform with industry: "(1) What do scientists and engineers say about boundaries between academe and industry? (2) What boundary maintenance and disputes do scientists and engineers engaged with industry encounter? (3) What quandaries do scientists and engineers face as they negotiate these new boundaries? (4) What new opportunities do scientists and engineers talk about?" (p. 132). Data for this study were gathered, as part of a larger initiative by the National Science Foundation, "from 38 semi-structured interviews with faculty who had interacted with industry in the past five years" (p. 132). The home institutions of these scientists were predominantly research universities with significant ties to industry.

Researchers contacted vice presidents for research at these institutions and requested the names of faculty with relatively extensive experience with for-profit organizations. Of the 38 participants in the final sample, 10 were department heads or directors of centers, while the additional 28 were faculty members. Four of the participants were female, and all but three were associate or full professors. Half of the sample was comprised of engineers, with the remaining participants coming from the sciences (12) or medicine (7). Participants held a wide variety of roles with industry. While some faculty members had served as consultants (predominantly with large firms), others had created start-up businesses and held patents. The participants' range of experiences accounted for most of the types things discussed in academy-industry relationships.

Initial data analysis presented three distinct trends among the responses: 1) a sense of "shifting boundaries" (p. 133) in regard to the relationships of faculty with industry, 2) shifting boundaries resulting in dilemmas or "quandaries" (p. 133) for the scientists, and 3) "the telling of mythical stories about colleagues' collaborations with industrial partners" (p. 133). Scientists' conversations about these themes demonstrated the "reshaping [of] professional norms and values" (p. 134) that is accompanying these new research agendas.

As mentioned before, one of the main topics of conversation among participants was the transition and reformation of boundaries typically established between universities and industry. For example, boundaries seem to be shifting in regard to federal versus corporate grants and funding. Scientists suggested the stigma formerly surrounding corporate funding is waning, and federal funding is far from the only game in town, especially since this money seems harder and harder to obtain. Another eroding boundary is the one between basic and applied research, with scientists talking more about “interesting” work or work that is “publishable in well-regarded, peer-reviewed journals” (p. 138). The new dichotomy (instead of basic compared applied) seemed to be long-term versus short-term research, with participants clearly favoring long-term projects while lamenting the unwillingness of industry to fund such projects. These findings present convincing evidence that boundaries are certainly changing.

Another frequently discussed theme in the interviews was the dispute over boundaries between academic and industrial science. The first area in which disputes were commonly encountered was that of publishing results versus patenting products and processes. Although faculty described recurrent conflicts where patenting interfered with publication cycles, many attempted to make both endeavors palatable. The issue of patents brought to light another boundary dilemma: secrecy versus access. Once the steps have been taken to secure rights to a product or process, how was the patent used? Participants expressed concern about tactics used by some companies for their own competitive advantage and balked at the industry practice of obtaining patents in order to preclude others from working on similar research. For example,

> “professors were making the point that industries saw patents as valuable, not because they promoted discovery and free competition, but because they precluded it. Indeed, these professors thought industries saw patents as a strategic means of staking out future directions for product development, preventing investment in these areas on the part of other firms,” (p. 144).

This sentiment was also expressed in regard to consulting arrangements between faculty and industry. Faculty indicated that they were routinely asked to “sign nondisclosure agreements, deal with industry’s data management conditions, and submit their research papers for prepublication review” (p. 145). Ultimately, scientists often normalized the restrictions and the withholding as part of what industry needed to do to accomplish its work by being “willing to make excuses for the company” (p. 145) or doubting the gravity of potential legal complications. A final quandary described by participants was that of intellectual property ownership. Despite the complexity of these negotiations as well as the uncertain position of researchers in limbo between their academic institutions and their industrial partners, participants still professed the value of these types of relationships.

Finally, scientists wove great narratives about the ability of their peers to “transform discovery into public stock offerings and marketable products” (p. 152), resulting in lucrative start-up businesses. The authors described how participants would tell “stories that sounded something like fairy tales” (p. 153) involving unimaginable accomplishments and successes. Slaughter and colleagues observed that these tales of grandeur were rarely accompanied by concerns over how this affected the work of faculty members in traditional academic institutions, nor other conflict of interest issues. In fact, the authors of this study indicated many such conflicts were missed or ignored by participants discussing this evolving arena for academic research.

The authors conclude that while faculty members are well aware of the shifts and negotiations regarding boundaries between academe and industry, there is not always complete acknowledgement of the resulting complications.

Relationships between Department Chairs and Industry: Campbell, E.G., Weissman, J. S., Ehringhaus, S., Sowmya, R. R., Moy, B., Feibelmann, S. and Goold, S. D. (2007). Institutional Academic Industry, Relationships. *Journal of the American Medical Association, 298*(15), 1779-1786.

Campbell and co-authors (2007b) conducted a national survey of medical school department chairs at 140 institutions throughout the country. The goal of this study was to understand, "the nature, extent, and consequences of IAIRs (institutional academic-industry relationships)," (p. 1779) and the population sampled was surveyed because, "the attitudes and experiences of department chairs are significant because they manage the primary organizational structure of medical schools and teaching hospitals" (p. 1779). Included in the sample were 125 accredited medical schools and 15 of the "largest independent teaching hospitals in the United States" receiving "the largest amount of funding from the National Institutes of Health in 2004" (p. 1780). From each institution, researchers attempted to sample four chairs were selected from clinical areas (medicine, psychiatry, and 2 randomly selected departments), while an additional 2 nonclinical chairs were selected (microbiology and one randomly selected nonclinical department). Surveys were sent to participants via e-mail. Chairs in the sample who did not respond via email were mailed paper surveys. Ultimately, 751 chairs were sampled, and of that group, 688 were found to be eligible for participation. The survey had an overall response rate of 67 percent (459 participants), with similar rates for clinical versus nonclinical department chairs. Respondents were predominantly men (89 percent) and were the acting chair (90 percent).

Results from this study demonstrate that although a relatively small proportion of the chairs had served as executive officers (7 percent), founders (9 percent) or members of boards of directors (11 percent) of companies, many more had served as paid consultants (27 percent) or members of advisory boards (27 percent). Many respondents had multiple personal roles with industrial organizations. Overall, on an individual level, approximately 60 percent of department chairs “had some form of personal relationship with industry” (p. 1782). At the department level, 80 percent of clinical and 43 percent of nonclinical departments had some type of relationship with industry. These relationships were (for example) defined as: receiving resources such as equipment, unrestricted funding for departmental operations, support for students, support for training and seminars, support for continuing medical education, money from licensing or transfer of intellectual property, or discretionary funding for food, travel, software, equipment, or faculty bonuses. More than a quarter of all departments had received (in each category) support for seminars, training and continuing medical attention. In fact, in clinical departments, 65 percent of continuing medical education was funded by industry. Almost 70 percent of departments had more than one relationship (as defined above) with industry.

Another interesting result of this study was the finding stating that department chairs perceived smaller gifts and unrestricted gifts as having fewer detrimental effects on the department than larger or restricted gifts. The authors cited evidence from a 2003 study by Dana and Lowenstein concluding “even small gifts and ones without restrictions can influence actions without being tied to explicit demands” (Campbell, p. 1785).

In regard to the impact of connections with industry (ability to provide educational offerings, bring in industry-sponsored funding, increase financial stability, and retain and recruit faculty), department chairs considered their personal relationships to businesses as having either no effect or positive effects. Virtually none of the participants reported that these individual relationships would have any negative effects on their departments. The same was true for the overall impact of relationships between the department and industry. In fact, for these relationships (whether at the department or individual level), chairs reported, more likely than not, that the relationships had no effect on the welfare of the department. In response to this finding, the authors asked, "If the majority of IAIRs have no effect on these important functions of departments, then why to they exist?" (p. 1785).

The authors conclude the study by speculating that social desirability bias, or the desire by surveyed department chairs to demonstrate they are not swayed by their own industry connections, may have led to underreporting the frequency and importance of the IAIRs.

Relationships between Physicians and Industry: Campbell, E.G., Gruen, R. L., Mountford, J., Miller, L. G., Cleary, P. D., and Blumenthal, D. (2007a). A National Survey of Physician-Industry Relationships. *New England Journal of Medicine, 356*(17), 1742-1750.

Another recent study by Campbell and colleagues (2007a) examines the financial relationships between physicians and industry, as well as "the factors that predict those associations" (p. 1742). The authors sought empirical evidence regarding the frequency of contact between physicians and industry, gifts or resources given to physicians by industry, and "characteristics associated" (p. 1743) with these relationships.

The authors sampled 3504 physicians in primary care, medical specialties, surgical specialties, and inpatient specialties. From the original sample, 3167 were considered eligible, and 1662 (52 percent raw response rate, 58 percent weighted response rate) responded to the paper questionnaire. Respondents were (all future percentages reported as weighted percentages) 73 percent male, and 91 percent non-underrepresented (Caucasian or Asian). The range of years in practice was well distributed, with similar levels responding from all divisions of years of service. Specialties included: family practice, 24 percent; cardiology, 7 percent; internal medicine, 32 percent; pediatrics, 17 percent; surgery, 8 percent; and anesthesiology, 12 percent. Primary practice organizations included: hospitals or clinics, 11 percent; universities or medical schools, 11 percent; group practice, 44 percent; 1- or 2-person practice, 24 percent; staff-model HMO, 6 percent, and other, 5 percent. Ninety percent of respondents were reviewers for professional journals and 61 percent were involved in the development of clinical practice guidelines.

In regard to industry, almost all of the respondents (94 percent) “reported some kind of relationship with industry in the previous year” (p. 1746). Specifically, 78 percent of respondents had received drug samples, 83 percent had received gifts (usually food in the workplace), 53 percent had been reimbursed for admission to or expenses for meetings, and 28 percent had received payment for serving on boards or as consultants. There were, however, significant differences based on area of specialty, type of actual relationship with industry, and the organization where physicians practiced. For example, physicians in group practices were anywhere from three to six times more likely to receive drug samples, gifts, and payment than physicians in hospitals, clinics, and HMO’s. In regard to contact with industry, family practitioners reported 16 meetings per month, while cardiologists and pediatricians met with industry representatives almost 9 times per month. Male physicians were significantly more likely to have industry relationships, as were physicians who had low numbers of uninsured or Medicaid patients (less than 25 percent of total patient population). Physicians involved in training or developing clinical guidelines were also significantly more likely to have relationships with industry, signifying—according to the authors—that these particular physicians are being targeted by industry.

The authors also highlighted other patterns that suggested the concentration of energy by industry representatives by physician’s specialty and perceived peer influence. For example,

> “cardiologists, whose prescribing patterns as specialists and opinion leaders are thought to influence the prescribing patterns of non-specialists, are significantly more likely to receive payments from companies than are physicians in other specialties” (p. 1747).

In addition, physicians in smaller organizations were likely to have more relationships with industry, perhaps—suggest the authors—because they have more freedom (and fewer official policies) to dictate their own prescribing practices.

Due to the practically ubiquitous nature of interaction between physicians and industry, the authors called for extensive and continued investigation into the implications of these relationships. As the relationships were so clearly influenced by specialty and type of practice, the authors believe that the development of “guidelines and recommendations […] specific to the context” (p. 1749) is likely necessary.

Conclusion

Connections between academia and industry will continue to grow in prevalence and scope, while providing important benefits to both partners in the relationship. As civic awareness and concern continue to develop around this topic, it will be important for leaders and observers to attend to data and details about the nature of these affiliations. Although empirical evidence regarding the types and frequencies of academy-industry relationships is growing, we need a better understanding of the opinions of the scientists involved in the actual partnerships. Specifically, do scientists involved in university-industry collaborations share the concerns of the researchers providing data about the nature of these aforementioned relationships? Understanding the perspectives of these scientists will provide critical insight into the rewards and challenges of scientific research in our nation's institutions of higher education.

CHAPTER 3: CONCEPTUAL FRAMEWORK & METHODOLOGY

This section presents the conceptual framework for the study and the study's methodology. First, central concepts of the research question are presented in relationship to one another, and all of the elements of the framework are examined and defined in relation to literature presented in the previous chapter. Next, the methodology of the study is presented, including methods being used, setting of the study, survey-design process, variables used in the analyses, sample selection process, data collection process, and data analyses.

Conceptual Framework

There is considerable evidence in the literature that science is changing and evolving, due in large part to connections between higher education and for-profit entities (Slaughter & Rhoades, 2004; Stein, 2004; Kennedy, 2003; Slaughter & Leslie, 1997). In this section of the dissertation, categories of variables, as well as specific measures within each category, are presented in connection to ideas represented in the literature.

Dependent Variables

As stated above, there is considerable evidence and commentary regarding the extent to which academic science is influenced by partnerships between academe and industry. There is empirical evidence to show the increase in size and scope of academy-industry relationships (AIRs), and many prominent scholars have offered informed observations on the impact of these connections (see, Campbell et al.. 2007; Campbell et al. 2007a; Slaughter et al., 2004; Campbell et al., 1998; Blumenthal et al., 1996a). The dependent variable of this project is scientists' perceptions of the market-orientation of science.

Recent studies regarding academy-industry relationships have raised concern about the impact of these connections on the process and content of academic science. For example, researchers working in conjunction with industry are often asked to engage in secrecy and withhold information about their research (Slaughter and Rhoades, 2004; Slaughter et al., 2004; Campbell et al., 1998; Blumenthal et al., 1996b), a practice that is in direct contradiction to communalism, a core principle of scientific inquiry according to Robert Merton (1942). Research also demonstrates that while certain levels of involvement with industry may increase a scientist's productivity, too much connection to industry leads to decreased "rates of publication and less influential articles than respondents with less support from industry" (Blumenthal et al., 1996a, p. 1736). Empirical evidence also demonstrates that research ethics may be at stake as well. In a study on scientific misconduct, over 15 percent of respondents indicated that they had changed "the design, methodology or results of a study in response to pressure from a funding source" (Martinson et al., 2005, p. 737). Such evidence suggests the importance of a cautious approach to institutional relationships.

In addition to concerns about the processes and quality of scientific research as a result of academy-industry relationships, there is also considerable unease about the priorities of institutions of higher education as these partnerships become increasingly prevalent. As scholars advocate for faculty research and service that are more aligned with the needs of local and regional communities, as well as reward structures that support this type of integration (Ward, 2005; Duderstadt, 2004), institutions continue the drive to market. Bolstered by policy changes at the institutional and federal level (Washburn, 2005; Slaughter and Rhoades, 2004), academic institutions are increasingly entrepreneurial. New directions in regard to academic capitalism have transformed the,

> “academic community into a mine [where] faculty must tunnel with the help of a small crew to unearth knowledge from veins or seams with commercial properties, which they present to technology licensing officials for evaluation” (Slaughter and Rhoades, 2004, p. 102).

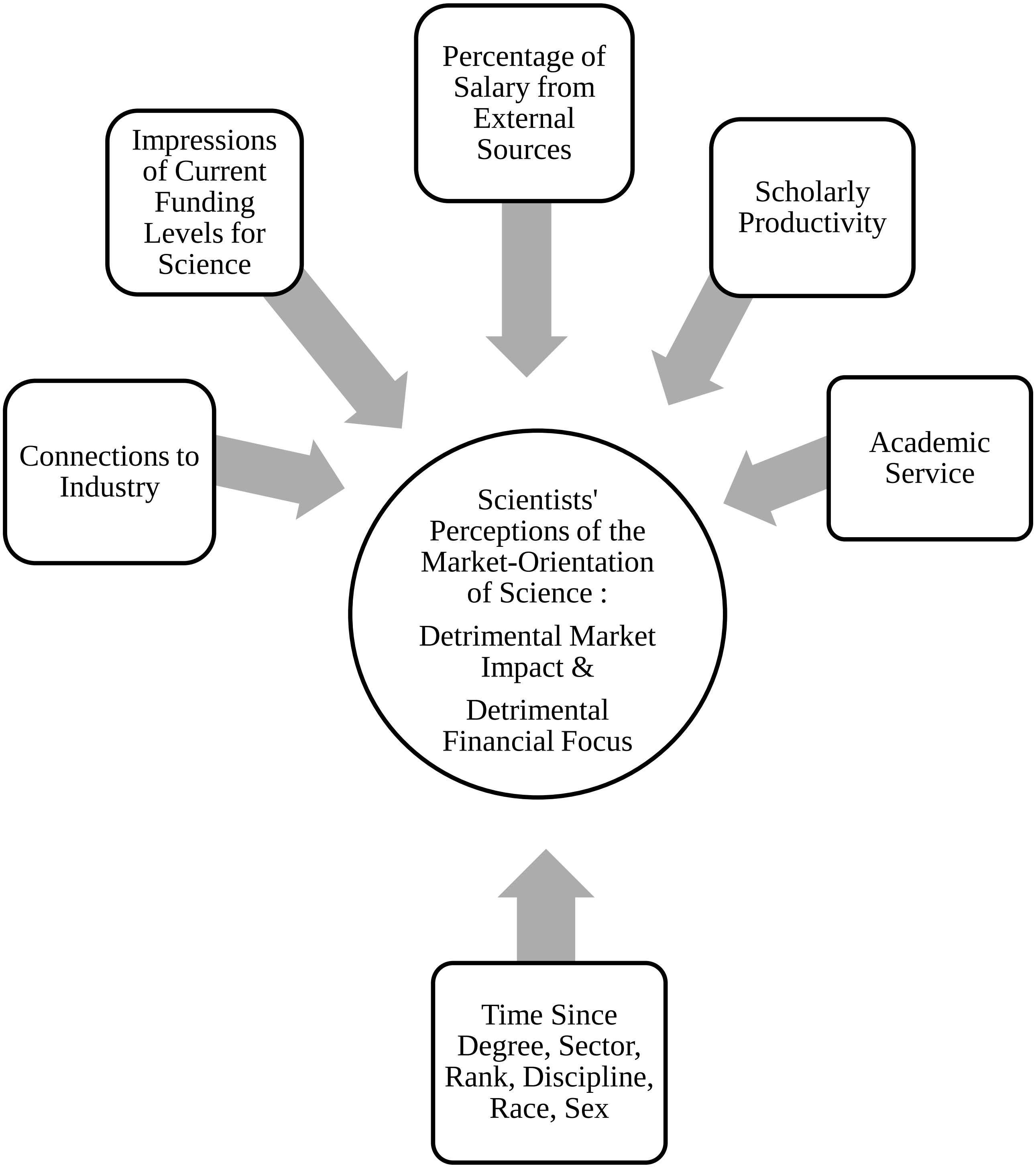
The literature demonstrates deep concern regarding the various changes in institutional goals and the impact on faculty work (Campbell et al., 2007b; Duderstadt, 2004; Slaughter and Rhoades, 2004; Slaughter et al., 2004; Bok, 2003 for example).

Less has been reported on scientists’ actual assessments of these partnerships. The dependent variables for this study are scientists’ perceptions of the extent to which the culture of academic science demonstrates a more market-oriented stance. Specifically, they are perceptions of a) the influence of soft-money positions in academia in regard to the quality of work being done, b) the extent to which there has been a shift towards research that is seen as financially profitable, c) the extent to which universities are more concerned about financial, rather than intellectual, rewards of research, and d) the extent to which the for-profit activities of researchers interfere with scientific progress.

Independent Variables

This study examines scientists’ perceptions of the market orientation of science. The goal is to understand how researchers’ perceptions of the market-orientation of science are influenced by factors related to their own behaviors within academic-research

Figure 1: Conceptual Framework



environments. Independent variables for this project include scientists' connections to industry; perceptions of funding levels for research; funding sources for scientists' academic appointments; scientists' research productivity; and scientists' service in institutional, disciplinary, and national advisory capacities (see Figure 1).

A primary independent variable considered in this study is the number of connections a researcher has with industry. There are direct and indirect methods by which industry offers financial support to academic researchers. The direct forms include contracts and grants that provide direct financial support. Indirect support may take the form of continuing medical education classes, free drug samples, or the use of biomaterials or other equipment (Campbell, 2007; Campbell, et al. 2007a and 1998). Additional connections resulting from interactions with industry include applying for and receiving patents, receiving royalties from inventions, having products on the market, and having start-up companies that are the result of academy-industry relationships. This study is concerned with establishing whether a researcher's connection to industry influences their view of the market orientation of academic of science. Research demonstrates that faculty involved in these partnerships are likely to minimize the challenges (Slaughter, et al., 2004), while institutional leaders will often praise the value of academy-industry relations, while at the same time minimizing the potential influence these contributions may have over their own departments (Campbell et al., 2007b).

Another independent variable is scientists' perceptions of funding levels for academic science. Since much of the rationale for partnerships with industry is justified by the economic benefits, especially due to perceived funding shortages (Heller, 2006; Geiger, 2004; Slaughter & Rhoades, 2004; Bok, 2003; Slaughter & Leslie, 1997), it is appropriate to assess how scientists' perceptions of current funding levels for academic research relate to their perceptions of the influence of academy-industry relationships. Variables examined here are scientists' perspectives on the difficulty of obtaining funding compared to the past and on the extent to which the need to secure external funding interferes with the actual work that needs to be accomplished.

A third independent variable is the percentage of salary a researcher needs to obtain from external sources. As budgetary constraints continue to be a reality for many departments and institutions (Heller, 2006), and as external partnerships continue to be logical alliances for advancing knowledge and discovery (Bok, 2003), many faculty members will need to look to other sources for significant portions of their funding.

Scholarly productivity in regard to publications and grants is an additional independent variable. The literature demonstrates that connections with industry can influence a researcher's productivity (Blumenthal et al., 1996a). There is also concern about including the commercialization of research, along with research productivity, in promotion and tenure decisions (Holbrook et al., 2004). The study examines how researchers with varying levels of academic productivity perceive academy-industry relationships.

Finally, the study will examine the extent to which various service experiences influence a researcher's perceptions of the market orientation of science. Since service is an important element of the three-part mission of higher education (Lucas, 1994; Kerr, 1982), and it is also a factor in promotion and tenure decisions, it will therefore be considered as an independent variable. Service experiences will be divided into three categories: institutional service, disciplinary service, and service in a national capacity.

Demographic Variables

The demographic variables examined include time since first doctoral degree, sector of higher education in which a participant works (public or private), academic rank, academic discipline, race and sex. These factors likely influence the relationship between scientists' perceptions of academy-industry relationships and the various independent variables.

The literature suggests that a cultural shift in perceptions has taken place and that relationships with industry are not seen as controversial or objectionable as they were in the past (Kezar, 2004; Slaughter & Rhoades, 2004; Slaughter et al., 2004; Stein, 2004; Bok, 2003; Kennedy, 2003). Examining how faculty opinions of the market orientation of science differ based on the amount of time spent as a researcher will show if participants in this study feel similarly. Accordingly, length of time since first doctoral degree will be considered.

Funding structures for faculty salaries can differ by sector of higher education, since public and private institutions have different sources for financial support (Heller 2006; Lucas 1994). Accordingly, sector of higher education will be a demographic variable in this study.

There is also considerable evidence in the literature that scientists at different points in their careers have diverse experiences with and opinions regarding relationships with industry (Campbell et al., 2007a; Blumenthal et al. 1996a and 1996b) and that progress related to promotion and tenure influence the decisions academics make regarding their research agendas (Geiger, 2004; Holbrook & Dahl, 2004). Academic rank is included in this analysis.

The literature demonstrates that academy-industry relationships can often vary by discipline (Slaughter & Rhoades, 2004; Slaughter & Leslie, 1997; Blumenthal et al., 1996). Given that opportunities for and types of interaction with industry vary by academic discipline, opinions about these partnerships should also be examined. Consideration of how views differ by disciplinary area of the university will be a demographic variable in this study.

There are differences between the experiences of men and women in their roles as faculty (DesRoches, et al. 2010; Hearn, 1999; Toutkoushian & Bellas, 1999), as well as dissimilarities experienced by people of different racial groups (Hearn, 1999; Toutkoushian & Bellas, 1999). Race and sex will be included in the study in order to discern whether these larger, broad differences of experience also pertain to opinions regarding the market orientation of academic science. Data will therefore be examined to determine if sex and race influence the relationship between the independent variables and perceptions of academy-industry relationships.

Methodology

This section of the paper details the study's methodological approach, setting for the study, and process for developing the data collection instrument. I examine the survey items used as independent, dependent and demographic variables, and describe the sample selection process. Data collection and analysis are also overviewed.

Description & Justification of Setting

Data for this study are from a survey administered to 5,000 faculty members at leading research institutions in the United States. The project (NIH Grant #0509S73512) was led by Principal Investigator Brian Martinson of Health Partners Research Foundation. The investigators sought data from scientists who were working at research universities and actively involved in the research enterprise, that is, performing research, publishing in peer-reviewed journals, and seeking and obtaining grants for their work. Investigators sampled departments in biology, chemistry, medicine, social sciences, and health services due to the extensiveness of NIH funding in these fields at research institutions.

Data from scientists working in these environments are critical to investigating the questions posed by this study. Rationale for studying participants at these institutions includes, but is not limited to, pervasiveness of federal funding and academy-industry relationships at these types of institutions, rate at which scientific research is changing at these institutions, and, finally, connections these institutions have to the public and the public good.

While a wide variety of colleges and universities receive federal money and have connections to the for-profit sector, the vast majority of these institutions are concentrated in categories such as the ones sampled for this project. Institutions with the Carnegie classification of “comprehensive doctoral with medical/veterinary [schools],” as well as those who are members of the Association of American Universities, produce a significant proportion of the scholarly research that takes place in higher education institutions in the United States. Researchers at these types of institutions often have active research agendas, including federally-funded initiatives, and sometimes relationships with for-profit organizations.

Another justification for sampling scientists from this particular research setting is the pace at which these research institutions are changing due to partnerships with industry (Kezar, 2004; Slaughter & Rhoades, 2004; Washburn, 2005). Institutions in this sample are not the only ones with academy-industry partnerships, nor are they the only institutions receiving federal research dollars. There is, however, a different climate for these sorts of initiatives at the institutions included in the sample of this project. These institutions are likely experiencing the most significant impacts of these partnerships and changing the most because of them. Literature also shows that relationships with industry have spanned many levels of the research endeavor (Blumenthal et al., 1996a & 1996b; Campbell et al., 2007a, 2007b & 2006). From the life sciences to clinical research, and from department chairs and doctors to institutional review board members, the influence of industry is considerable.

A final consideration when thinking about the relevance of this particular setting is the fact that many of these institutions are public universities, and all of these institutions receive large sums of federal money. As such, the public has a vested interest in the activities of the sampled researchers. As discussed earlier in the literature review, many scholars and commentators have expressed concern about the impact of money from industry on the public good (for example, Geiger, 2004; Kezar, 2004; Slaughter & Rhoades, 2004). Given the concern about impacts of for-profit institutions and marketization on higher education in the United States, it is important to assess the perspectives of scientists working in institutions that benefit greatly from the financial support of the general public.

Data Collection Instrument

Although survey items were created specifically for the study at hand, researchers paid close attention to items from previous studies by Martinson, Anderson and DeVries (2005), Campbell, Weissman, Causino, and Blumenthal (2000), and Anderson (1996) measuring faculty productivity, professional connections to industry, and productivity resulting from these academy-industry relationships. Items related specifically to academic misconduct from the Martinson et al. (2005) study were revised and included in the current study. Many items were written specifically for this project. For example, there was a battery of items regarding scientists' perceptions of their field, as well as science in general. These environmental questions were created specifically for this project. The research team pretested the data collection instrument by administering it to several colleagues in fields of study similar to those that would be receiving the survey. Feedback offered by pretest participants was shared with the entire research team and appropriate changes were incorporated into the final survey.

Variables

The overall aims of the research project from which data were taken included examining connections between perceptions of organizational justice and scientific misconduct. Variables from the survey used in this study were modeled after items from earlier research projects.

Dependent Variables

While there were many research questions related to the larger project for which this survey was designed, the main goal of this particular part of the study is to understand scientists' perceptions of the increasing market orientation of science. Items used as dependent variables to measure scientists' opinions of the market-orientation of science came from the section of the survey pertaining to perceptions of their field and of science in general. The questions used as dependent variables measure to what extent respondents felt the market had a detrimental impact on science, as well as to what extent the financial focus of universities was detrimental to research. Specifically, respondents were asked to what extent they agreed with the following statements:

Detrimental Market Impact:

- "The growth of soft-money positions has had a detrimental impact on science."
- "For-profit activities of academic researchers interfere with the forward progress of science."

Detrimental Financial Focus:

- "The increase in industry funding of university-based research has shifted focus to areas that are seen as financially profitable."
- "Universities increasingly view academic research in financial terms, instead of intellectual terms."

Response choices for the four items listed above were: strongly agree (7), moderately agree (6), slightly agree (5), neutral (4), slightly disagree (3), moderately disagree (2), and strongly disagree (1).

Independent Variables

There are five independent variables in this study: connections to and productivity in the private sector, scientists' perceptions of funding levels for academic science, percentage of a researcher's salary that comes from outside the academic institution, research productivity, and various types of academic service.

Of the questions in the survey, 2 items were used in order to measure participants' connections to industry and their productivity in the private sector. One question asked, "In the past 3 years, including now, have you had any of the following relationships with a <u>private, for–profit company?</u> Please check all that apply." Participants could select from: founder/officer/executive, member of the board of directors, consultant/advisor, recipient of funding for university research, recipient of honoraria, and other (please specify). Another item related to academy-industry relationships stated "In the last 3 years, has the research that you do at your university resulted in any of the following? (Please check all that apply)," and response choices included: patents applied for, patents issued or licensed, trade secrets, royalties from inventions, a product under regulatory review, a product on the market, a start-up company. For each of these items, responses were coded: 0 if not checked, 1 if checked, and missing if none of the items were checked.

Another line of inquiry related to scientists' perceptions of funding levels for their work. Participants were asked to consider recent funding trends: "In the past two years, has obtaining federal funding for research in your field become: much more difficult (5), somewhat more difficult (4), stayed about the same (3), somewhat easier (2), or much easier (1)." Another item related to funding levels was taken from the section of the survey pertaining to scientists' general perceptions of the scientific environment. Participants were asked to what extent they agreed with the following statement: "The need for researchers to secure their own research funding interferes with the forward progress of science." Response choices were: strongly agree (7), moderately agree (6), slightly agree (5), neutral (4), slightly disagree (3), moderately disagree (2), and strongly disagree (1).

The independent variable, funding source for faculty appointment, was addressed by asking respondents, “What percentage of your salary is currently covered by external funds?” Respondents provided a percentage between 0 and 100.

Items used to measure a scientist’s research productivity addressed publications, grants and contracts, and other forms of institutional and professional service. In regard to publications, the survey asked “Approximately how many refereed journal articles have you published in your career?” Participants were asked to write in a numerical response. A related item asked, “For how many grants or contracts are you currently serving as the Principle Investigator or co-Investigator from each of the following sources?” The sources were: federal government, state/local government, private industry, foundations, university research funding, and other. For each of these categories, participants were asked to list separate numbers for grants and contracts on which they served as the Principle Investigator or co-Investigator.

Another independent variable included participation and service in the participant’s department, institution and field. Respondents were asked, “In the past 3 years, have you served as (please check all that apply):

- chair or head of an academic department
- director of a research center
- administrator above the level of your department or academic center
- chair of a university-wide committee
- member of a review panel or study section for a federal agency
- member of a board/review panel of a private foundation related to your work
- member of a board of directors of a non-profit organization related to your work
- editor or editorial-board member of a professional journal
- consultant to government
- consultant to a non-profit, non-governmental organization

- officer of a professional association
- member of a national advisory committee
- member of an honorary association (e.g. National Academy of Sciences)."

Responses were coded as follows: 0 if not checked, 1 if checked, and missing if none of the items were checked.

Demographic Variables

Certain demographic variables were accounted for prior to survey distribution. The sector of the respondent's home institution (public or private) was coded into hard copies of the survey before distribution. Discipline also was coded into hard copies of the survey before they were mailed to participants. Respondents also provided certain demographic data. Length of career was represented by the question, "In what year did you receive your first doctoral level degree?" Participants were asked to indicate the year. Participants were also asked to indicate their academic rank (assistant, associate, or full professor).

Demographic variables also included standard measures, such as sex (male or female) and race. Options for the race category included: White/Caucasian, Black/African-American, American Indian or Alaska Native, Asian, Native Hawaiian or Pacific Islander. Participants also had the option of writing in their own response. As a follow-up question, respondents were asked if they considered themselves to be Spanish, Hispanic or Latino. Participants were asked to circle male or female for the question "What is your sex?"

Sample Selection

A series of steps were taken in order to select a representative sample of research subjects for this study. Institutions, departments and research subjects were subject to a hierarchical sampling approach, with the goal of selecting 5,000 research subjects from 500 academic departments at 50 universities. As mentioned above, researchers wanted to survey subjects at premier universities with robust research agendas and significant levels of funding from the National Institutes of Health. To ensure inclusion of faculty at these types of universities, a list was created that included institutions from the Association of American Universities (AAU), as well as institutions with the Carnegie classification of "comprehensive doctoral with medical/veterinary [schools]." Institutions from these two listings provided a sample of 96 universities. Using an on-line random number generator, institutions were ranked from 1 to 96, with the first 50 universities included in the sample.

Next, policies for appropriate use of institutional directory information were consulted. If, per the statements on institutional websites, directory information was not to be used for purposes such as the external surveying of faculty, universities were removed from the sample and replaced with the next institution in the original list of 96. Fourteen institutions were removed from the sample for this reason. At this point in the construction of the institutional sample, 24 universities without medical schools were also excluded, due to the researchers' goals of gathering data from faculty in medical fields. Again, these universities were replaced with others from the original list of 96, ensuring a total sample of 50 institutions. Two additional factors influencing the final sample of 50 institutions included 1) the exclusion of an institution due to a natural disaster that took place during the creation of the sample, and 2) the exclusion of 3 institutions due to the limited functionality of institutional websites.

Once the top 50 universities were selected, researchers collected faculty directory web pages for a variety of departments at each institution. Websites were accumulated for as many of the following departments as were available at each institution:

- Social Sciences: anthropology, economics, psychology and sociology
- Biological Sciences: anatomy, biology, cell biology, ecology/evolutionary biology, microbiology, molecular biology, neurobiology, physiology
- Chemistry and biochemistry
- Medicine: cardiology, endocrinology, gastroenterology, general/internal medicine, immunology/rheumatology, infectious disease, neurology, oncology, pulmonary/asthma/allergy
- Health Services: biostatistics, dental/cranial/facial, epidemiology, health services research, kinesiology, nursing, nutrition, occupational therapy, physical therapy, pharmacology

The aforementioned departments were only included for consideration if they contained 11 or more faculty members. It was critical to find departments with 11 or more faculty so that 10 of them could be randomly selected, as described below. Upon completion of the list of all viable academic departments, 2 departments were randomly selected from each of the 5 disciplines (listed above) at each university. This provided a sample of 500 academic departments at the 50 institutions, with 10 departments being selected from each institution. Emphasis was placed on these disciplines due to the prevalence of research funding by the National Institutes of Health. Each of the 50 institutions, as well as the 500 departments, was assigned an individual code for use in future analyses.

Ten faculty members were then randomly selected from each of the 500 departments in the sample. When possible, these samples were drawn from departmental directories consisting exclusively of faculty. If faculty-only directories were not available, care was taken to exclude staff, administrators, and graduate students, as well as adjunct, visiting, and emeritus professors when selecting the research subjects. The goal was to select a sample of subjects with ongoing research experiences and responsibilities. Ten research subjects were chosen from each of the 500 previously sampled departments, creating an overall sample of 5,000 participants. Complete surveys were received from 1,703 participants, for an overall response rate of 34.65 percent.

Although clinical professors, lecturers and other research staff also comprised a portion of the respondents, this study focuses on the responses of faculty in the aforementioned ranks. Faculty members are most likely to have the sorts of academic experiences that are juxtaposed with dependent variables related to the increasing market orientation of science, such as relationships with industry, as well as engagement in the types of scholarly productivity and service that are of interest in this study. This study is therefore based on a subset of respondents, those with faculty appointments. This subset of faculty yielded 1,554 respondents for the analyses, of which 51.9 percent were professors, 22.3 percent were associate professors, and 25.8 percent were assistant professors. The results of this dissertation are based on this particular subsample, and the respondents under consideration throughout the study are the members of this subset.

This project had co-investigators residing at two institutions, one academic and one non-profit/non-academic. Prior to data collection, approval was sought and received from the Institutional Review Boards at both of the investigators' home institutions.

Data Collection Process

A fourteen-page survey was mailed to the 5,000 members of the sample. The preliminary mailing took place in October of 2006. Respondents received a packet containing a copy of the survey instrument, a letter from the researchers describing the project, a postcard with a unique identification number, a postage-paid return envelope for the survey, and a $2.00 bill as a token incentive for participation. Surveys were mailed back to one of the co-investigators, while the postcard was mailed back to the principal investigator. These items were kept separate at all times to ensure the anonymity of the participants. When the postcard was received, the participant with the corresponding identification number was removed from the mailing list, so as not to be included in the re-mailing of the survey. This re-mailing took place in November of 2006, approximately one month after the initial mailing. It included a copy of the survey instrument, a letter from the researchers, and a return envelope. This mailing was only sent to sample members who had not yet returned a postcard.

In order to keep better track of the returned surveys, codes were discreetly included at the bottom of the first page, allowing researchers to specifically identify from which university and department the returned survey came. The codes provided a mechanism for clustering analyses both by institution and by field of study. It was also possible to assess nonresponse bias, based on information provided from the codes (Crain et al., 2008). After the data were recoded to allow analyses by institution and department, the crosswalk containing identifying information was destroyed, maintaining the anonymity of respondents' home universities and departments. Thus data could be analyzed by institution and department, but there was no way to track from which place the survey actually came. Returned surveys were also coded according to the date when they were received by the co-investigator. All returned surveys were sent to a punch-key data processing organization, where the data were electronically entered.

CHAPTER 4: ANALYSIS OF FINDINGS

In this chapter, results of statistical analyses are examined in regard to the central research question of this study: How do scientists' academic and professional experiences, including connections to industry, current funding levels for science, funding sources, scholarly productivity, and academic service influence scientists' perceptions of the market orientation of science? Descriptive analyses are presented, as well as analysis of means and correlations of key variables. Finally, the results of regression analyses are examined, indicating which of the independent and demographic variables are most significantly related to scientists' perceptions of the market orientation of science.

Descriptive Findings

There are two dependent variables for this study (see Table 1). One variable indicates participants' opinions about the extent to which the market orientation of academic research is

problematic in regard to the progress of science. This variable was created by summing the following items, for which participants were asked how strongly they agreed or disagreed on a scale from strongly disagree (1) to strongly agree (7): "The growth of soft-money positions has had a detrimental impact on science," and "For-profit activities of academic researchers interfere with the forward progress of science." This variable, "detrimental market impact," had a range from 2 to 14, and a mean of 9.174, demonstrating that, overall, researchers are somewhat concerned about the impact market orientation has on academic research. The second dependent variable, designed to

Table 1: Descriptive Statistics for Dependent Variables (N=1554)

Scale	**Mean**	**Standard Deviation**	**Range**
Detrimental Market Impact:			
The growth of soft money positions has had a detrimental impact on science.	4.73	1.638	1-7
For-profit activities of academic researchers interfere with the forward progress of science.	4.44	1.478	1-7
Detrimental Financial Focus:			
The increase in industry funding of university-based research has shifted focus to areas that are seen as financially profitable.	5.31	1.296	1-7
Universities increasingly view academic research in financial terms, instead of intellectual terms.	6.10	1.160	1-7

Response categories: *1=Strongly disagree; 2=Moderately disagree; 3=Slightly disagree; 4=Neutral; 5=Slightly agree; 6=Moderately agree; 7=Strongly agree* measure participants' perceptions of the financial focus of universities, reflects the extent to which respondents agreed or disagreed with the following items: "The increase in industry funding of university-based research has shifted focus to areas that are seen as financially profitable," and "Universities increasingly view academic research in financial terms, instead of intellectual terms." This variable, "detrimental financial focus," had a range of responses from 3 to 14, and a mean of 11.410. There is considerable agreement among respondents that universities view academic research in terms of economic gain.

The five categories of independent variables used in this study are relationships with industry and the results of these academy-industry relationships; perceptions about the current climate for securing research funding; scholarly productivity; percentage of salary that researchers must secure from external sources; and service in institutional, professional and national capacities. Table 2 presents the means of these variables.

The extent to which respondents are engaged in relationships with industry is one of the primary independent variables in the study. The scale was created by summing each respondent's experiences with industry, as well as the tangible results of these interactions. The variable regarding relationships with industry included serving in any of the following capacities in the past three years: founder/officer/executive; member of the board of directors; or consultant/advisor of a private, for-profit company. Relationships with industry were also indicated by funding for university of research or other honoraria for their efforts. Additional components of relationships with industry included the following: patents applied for, patents issued or licensed, trade secrets, royalties from

Table 2: Descriptive Statistics for Independent Variables (N=1554)

	Mean	**Standard Deviation**	**Range**
<u>Relationships with and Results of Academy-Industry Relationships:</u> In the past 3 years, including now, have you had any of the following relationships with a private, for-profit company: founder/officer/executive; member of the board of directors; consultant/advisor; recipient of funding for university research; recipient of honoraria? *0=No; 1=Yes* In the last 3 years, has the research that you do at your university resulted in any of the following: patents applied for; patents issued or licensed; trade secrets; royalties from inventions; a product under regulatory review; a product on the market; a start-up company? *0=No; 1=Yes*	.96	1.60	0-10
<u>Difficulty of Obtaining Funding:</u> In the past two years, has obtaining federal funding for research become… *1=Much more difficult; 2=Somewhat more difficult; 3=Stayed about the same; 4=Somewhat easier; 5=Much easier*	1.54	.72	1-5
<u>Interference of Funding Process:</u> The need for researchers to secure their own research funding interferes with the forward progress of science. *1=Strongly disagree; 2=Moderately disagree; 3=Slightly disagree; 4=Neutral; 5=Slightly agree; 6=Moderately agree; 7=Strongly agree*	4.51	1.66	1-7
<u>Scholarly Productivity: Grants</u> For how many research grants or contracts are you currently serving as the Principal Investigator or co-Investigator?	4.45	4.74	0-75
<u>Scholarly Productivity: Journal Articles</u> Approximately how many refereed journal articles have you published in your career?	62.85	82.50	1-1201
<u>Amount of External Funding:</u> What percentage of your salary is currently covered by external funds?	27.47	31.74	0-100
<u>Service: Institutional</u> In the past three years, have you served as: chair or head of an academic department; director of a research center; administrator above the level of your department or center; chair of a university- wide committee?	.45	.73	0-4

0=No; 1=Yes			
<u>Service: Professional Associations</u> In the past three years, have you served as: editor or editorial-board member of a professional journal; officer of a professional association; member of an honorary association (e.g. National Academy of Sciences)? *0=No; 1=Yes*	.77	.85	0-3
<u>Service: National Advisory Roles</u> In the past three years, have you served as: member of a review panel of study section for a federal agency; member of a board/review panel of a private foundation related to your work; member of a board of directors of a non-profit organization related to your work; consultant to government; consultant to a non-profit, non-governmental organization; member of a national advisory committee? *0=No; 1=Yes*	1.28	1.34	0-6

inventions, products under regulatory review, products on the market, or start-up companies.

The academy-industry relationship variable had a range from 0 to 10, and a mean of .960. Although 58.5 percent of participants did not have any relationships with private, for-profit companies, 18.1 percent reported having one connection to industry, while 10.6 percent and 5.2 percent had 2 or 3 connections, respectively. Additionally, 7.6 percent of the surveyed participants had as many as 4 to 10 relationships with private businesses, either through roles they played in the organization or through results of their academic research.

Another category of independent variable examined respondents' opinions regarding the climate for obtaining funding for academic research. The item "In the past two years, has obtaining federal funding for research become: much more difficult (1), somewhat more difficult (2), stayed about the same (3), somewhat easier (4), or much easier (5)," had a mean of 1.54. Responses to the question about the extent to which "the need for researchers to secure their own research funding interferes with the forward progress of science" (1 = Strongly Disagree, 7 = Strongly Agree), yielded a mean of 4.51, which indicates the perceived challenges researchers face when pursuing resources for their work.

Research grants and refereed journal articles were used as measures of scholarly productivity. Almost 82 percent of the participants had served as principal or co-principal investigators, with the actual number of grants per respondent ranging from 0 to 75. The mean number of grants was 4.45. Variation in number of publications was considerable, with the range stretching from one to 1,201 journal articles. On average, participants had 63 refereed publications.

The extent to which researchers need to obtain external funding may influence their perceptions of the market-orientation of academic research. Survey participants were asked to report what percentage of their salary was currently covered by external funds. The range of responses was from 0 to 100 percent, with a mean of 27.5 percent.

The institutional service variable was created by summing four components of an item designed to measure recent service experiences at a participant's home campus. Respondents were asked if they had, in the past three years, served as chair or head of an academic department; director of a research center; an administrator above the level of department or center; or chair of a university-wide committee. Responses to the institutional service variable ranged from 0 to 4 service roles. The majority of participants had no service of this type, with 66.7 percent selecting none of the options. Of the respondents with service experiences at their current academic institutions, 23.3 percent had one experience, 8.6 percent had two experiences, 1.2 percent had three experiences, and .3 percent had participated in all four types of institutional service.

Survey participants were also asked about service experiences within the context of the professional organizations in their academic fields. Respondents were asked if they had, in the past 3 years, served as an editor or editorial-board member of a professional journal; an officer of a professional association; or a member of an honorary association (e.g. National Academy of Sciences). Responses to this item ranged from 0 to 3 possible service experiences within the context of professional associations, with 46.7 percent of respondents indicating that they had not participated in any of the aforementioned activities. The majority of respondents were engaged in this type of activity, with 33.9 percent indicating at least 1 service experience with their professional associations. Another 15.6 percent of participants had 2 service experiences, and 3.8 percent had all 3 types of service experiences within their professional associations.

The final type of service measured by the survey was participation in an advisory capacity at a national level. Respondents were asked if they had any experiences, in the last 3 years, as a member of a review panel or study section for a federal agency; a member of a board/review panel of a private foundation related to their academic work; a member of a board of directors of a non-profit organization related to their work; a consultant to government; a consultant to a non-profit, non-governmental organization; or a member of a national advisory committee. Response categories ranged from 0 to 6 service opportunities, with 36.6 percent of survey participants saying they had not engaged in any of these types of service. Most survey participants had either 1 or 2 of these types of broad, national service roles, 27.5 percent or 18.5 percent respectively. Ten percent of respondents had 3 of these service experiences, while 4.7 percent had engaged in 4 of these types of opportunities. In the 3 years prior to the administration of this survey, 2.1 percent had taken part in 5 of these service activities, and 0.6 percent had engaged in all 6.

Demographic variables, presented in Table 3, used in this study include the sector of higher education in which the respondent's institution was located, academic rank, academic discipline, years since participants received their doctoral degree, as well as race and gender.

Table 3: Descriptive Statistics for Demographic Variables (N=1554)

Variable	**Percent**
Sector	
Private	21.6%
Public	78.4
Rank	
Professor	51.9
Associate Professor	22.3
Assistant Professor	25.8
Discipline	
Biology	24.3
Chemistry	19.0
Health	21.4
Medicine	13.8
Social Science	21.3
Race	
Caucasian	86.0
Person of Color	14.0
Gender	
Male	64.2
Female	33.5

Variable	**Mean**	**Standard Deviation**	**Range**
Time Since Degree	22.26	11.87	1-61

As described in Chapter 3, the institutional sample for this study was created by randomly selecting 50 institutions from a list of 96 schools that either held the Carnegie classification "comprehensive doctoral with medical/veterinary [schools]," or were members of the Association of American Universities. Of the survey respondents, 78.4 percent were faculty at public institutions and 21.6 percent were faculty at private institutions. In regard to field, 24.3 percent of the participants were from biology, 21.4 percent from health, 21.3 percent from social sciences, 19 percent from chemistry, and 13.8 percent from medicine. Originally, each of the fields comprised an equal 20 percent of the sample.

As indicated earlier in the methodology sections, this study is based on a subsample of respondents who indicated they were professors, associate professors, or assistant professors. This subset of faculty yielded 1,554 respondents for the analyses, of which 51.9 percent were professors, 22.3 percent were associate professors, and 25.8 percent were assistant professors.

Participants were asked to indicate in which year they received their first doctoral-level degree. Time since doctorate was 22 years on average. Faculty in the earlier stages of their careers (ten or fewer years since the completion of their doctoral degrees) made up 20.5 percent of the sample. Faculty who had earned their doctoral degrees between 11 and 20 years prior accounted for 25.5 percent of the respondents, while 26.5 percent of the participants fell into the 21 to 30-year category. Twenty-one percent of respondents had earned their first doctoral degree 31 to 40 years before, and 6.5 percent of participants had received their first PhD over 40 years ago.

White or Caucasian participants made up 86 percent of the sample. African American, American Indian/Alaska native, Asian, Native Hawaiian/Pacific Islander, and Latino respondents made up the additional 14 percent of the sample. According to the *Chronicle of Higher Education*, in the fall of 2007, 78.1 percent of the faculty in the United States were white or Caucasian and 21.9 percent were faculty of color (*Almanac of Higher Education*, 2010). White participants were somewhat overrepresented in this sample, compared to the national average.

In regard to gender, 64.2 percent of survey respondents for this study indicated they were male and 33.5 percent indicated they were female, while 2.3 percent of the participants chose not to respond to this item. Nationally, according to the *Chronicle of Higher Education*, in the fall of 2007, 58.2 percent of faculty members were men and 41.8 percent were women (*Almanac of Higher Education*, 2010). Male faculty were somewhat overrepresented in this sample, compared to the national average.

Analytic Findings

Means Analyses

Means analysis of variables used in the study provides insight into how various categories of respondents answered questions differently. Table 4 shows that there were no statistically significant differences in how any of the groups of respondents answered the question about the detrimental financial focus of universities in regard to the economic advantages of certain types of academic research. There were, however, two significant differences in regard to the dependent variable concerning the detrimental

Table 4: Analysis of Variance by Demographic Variables

	Detrimental Market Impact (Range = 2-14)	Detrimental Financial Focus (Range = 3-14)
Sector		
Public	8.96	11.18
Private	8.68	10.96
Rank		
Professor	8.81*	11.17
Associate Professor	8.76	11.14
Assistant Professor	9.22	11.04
Discipline		
Biology	9.05	11.32
Chemistry	9.01	11.32
Health	8.73	11.03
Medicine	8.82	11.01
Social Science	8.86	10.94
Race		
Caucasian	8.84*	11.15
Faculty of Color	9.32	11.01
Gender		
Male	8.94	11.18
Female	8.99	11.19

Significance Levels: *p<.05, **p<.01, ***p<.001.

market impact on scientific research. The demographic variables of rank and race were both significantly related to the dependent variable for detrimental market impact.

The academic rank of respondents was significantly related to perceptions of the detrimental impact of the market on scientific research. Associate professors, with a mean score of 8.76 (in a range of 2 to 14), were less likely to feel that market orientation was detrimental to science than were full professors (8.81) and assistant professors (9.22).

There was also a significant difference in regard to detrimental market impact for race. Means comparisons by racial group demonstrate a significant difference between perceptions of white participants and perceptions of participants of color. Specifically, white participants had a mean score of 8.84 (in a range of 2 to 14), whereas participants of color had a mean score of 9.32, indicating stronger negative perceptions among faculty of color.

Means comparisons of the independent variables (connections to industry, access to funding, interference of funding process, and external salary dependence) demonstrate differences by demographic variables. In terms of numbers of connections to industry (see Table 5), full professors have significantly more of these relationships on average (1.26) than do associate (.74) and assistant (.55) professors.

Variation in number of academy-industry relationships by group was also found in regard to discipline. That different areas of the academy have distinctly different interactions with industry is not particularly surprising, though the actual magnitude of these differences might be illustrative of disparities of resources and other inequities throughout academic research. Faculty in the social sciences had the fewest connections to industry (.32), followed by faculty in health-related departments (.75). The means for both of these disciplines were below the overall mean (.96). Areas of the academy with the most connections to industry were chemistry (1.49), medicine (1.36) and biology (1.07).

Finally, there was also a highly significant difference between male and female respondents in regard to connections to industry. The mean number of academy-industry relationships was 1.16 for men and .59 for women.

Another set of items measured participants' observations about funding (see Table 5). One question asked about the extent to which it had become harder to obtain funding over the course of the last two years. For the first of these items, respondents were uniformly pessimistic about the climate for obtaining funding. Means for all groups fell well within the categories of "Somewhat more difficult" or "Much more difficult" in response to the question about the ease of obtaining federal funding. While neither sector, academic rank, nor the gender of the respondent influenced this perceived degree of difficulty, academic discipline and race proved to be significant in regard to how much more taxing the chore of obtaining funding had become. Though respondents from no part of the academy actually believed the process of obtaining funding had gotten easier, faculty members in the social sciences were the least pessimistic (1.93) and faculty members in biology were most pessimistic (1.32). Scholars of color (1.42) had a starker view of these challenges than did white faculty (1.56).

The second item relating to financial support asked about the extent to which a researcher's need to secure her own funding interferes with the forward progress of science (see Table 5). Although sector of higher education was not related to the responses, all other demographic categories were significant. Assistant (4.81) and

Table 5: Analysis of Variance of Connections to Industry, Access to Funding, Interference of Funding Process, and External Salary Dependence by Demographic Variables

	Connections to industry	Access to funding	Interference of funding process	External salary dependence
Sector				
Public	.94	1.55	4.51	24.79***
Private	1.05	1.49	4.47	37.54
Rank				
Professor	1.26***	1.55	4.30***	26.90
Associate Professor	.74	1.53	4.62	26.29
Assistant Professor	.55	1.51	4.81	29.63
Discipline				
Biology	1.07***	1.32***	4.47**	33.21***
Chemistry	1.49	1.44	4.23	22.16
Health	.75	1.54	4.82	35.38
Medicine	1.36	1.47	4.57	41.32
Social Science	.32	1.93	4.43	8.54
Race				
Caucasian	.97	1.56**	4.44***	26.83
Faculty of Color	.91	1.42	4.92	31.38
Gender				
Male	1.16***	1.56	4.40**	27.02
Female	.59	1.50	4.71	27.85

Significance Levels: *p<.05, **p<.01, ***p<.001.

associate (4.62) professors believed the search for funding interfered more with the process of science than did full professors (4.30), though this may also be related to the pressures on productivity that are often felt more acutely by junior faculty members. There were also significant but modest differences across academic disciplines. Chemists were least concerned (4.23), while scientists from health fields were most concerned (4.82). Faculty members of color (4.92) felt the funding processes interfered with their scholarship more so than their white colleagues (4.44). Finally, women (4.71) were significantly more likely than men (4.40) to see the interference of the funding processes with their scholarship.

A final independent variable was the percentage of salary garnered from external sources (see Table 5), or external salary dependence. Faculty members at private institutions were more likely to have a higher percentage of their salary (37.54%) from an external source than were their counterparts at public institutions (24.79%). There were also significant differences based on academic discipline. Respondents from medicine (41.32%) and social sciences (8.54%) were on opposite ends of the spectrum in regard to percentages of income from external sources. Faculty members in chemistry found just over a fifth (22.16%) of their funding outside the academy, while scientists in biology (33.21%) and health (35.38%) procured about a third of their research dollars externally. Given the distinctly different nature of the types of research done in each of the disciplines, these differences are not surprising (Washburn, 2005; Hall, 2004; Rai, 2004; Bok, 2003; Slaughter & Leslie, 1997).

Table 6 presents a means analysis of scholarly productivity by demographic variables. Productivity was measured by the number of grants on which a respondent

Table 6: Analysis of Variance of Independent Variables for Scholarly Productivity and Service

	Scholarly Productivity Grants	Scholarly Productivity Articles	Service: Institutional	Service: Professional Associations	Service: National Advisory Roles
Sector					
Public	4.41	61.21	.44	.77	1.25
Private	4.60	68.74	.49	.76	1.37
Rank					
Professor	4.97***	99.15***	.66***	.98***	1.63***
Associate Professor	4.09	33.11	.38	.72	1.16
Assistant Professor	3.71	14.76	.088	.36	.65
Discipline					
Biology	4.97	77.86	.45	.69	1.28
Chemistry	4.33	90.83***	.40	.61	1.17
Health	4.59	48.89	.47	.97***	1.59***
Medicine	5.73***	59.46	.44	.62	1.22
Social Science	2.98	36.95	.49	.89	1.08
Race					
Caucasian	4.56*	66.41***	.49***	.81***	1.32**
Faculty of Color	3.79	41.19	.21	.52	.99
Gender					
Male	4.60*	74.51***	.50**	.70	1.30
Female	4.04	39.48	.36	.87***	1.22

Significance Levels: *p<.05, **p<.01, ***p<.001.

served as principal or co-principal investigator, as well as number of publications in peer-reviewed journals. As expected, there were highly significant differences in scholarly productivity based on academic rank, with full professors having more grants and publications than their more junior counterparts. Professors reported an average of 4.97 grants and 99.15 publications, while associate professors indicated a mean of 4.09 grants and 33.11 publications. Assistant professors, with the least amount of active research time thus far in their careers, had participated as principal or co-principal investigators for 3.71 grants and had published 14.76 articles.

Highly significant differences in regard to the measures of publications and grants by academic discipline are not surprising, as there is variation in expectations and norms in regard to scholarly productivity across disciplines. Respondents in the social sciences had the lowest means for both grants (2.98) and publications (36.95). Respondents from medicine were most active when it came to grants, with a mean score of 5.73, followed by faculty in biology (4.97), health (4.59) and chemistry (4.33). Participants from chemistry had the highest mean score in regard to publications (90.83), followed by biology (77.86), medicine (59.46) and health (48.89).

Finally, the results of this study echo the findings of other research suggesting that women and faculty members of color are often less productive in regard to some of the more traditional measurements of academic work (Ash et al., 2004; Valian, 1999). In regard to number of grants on which respondents had been investigator or co-investigator, faculty of color had a mean score of 3.79, while white faculty had a mean score of 4.56. Women had a mean score of 4.04, while men had a mean score of 4.60.

For both women and faculty members of color, there were significant differences between their average number of peer-reviewed publications and that of men and white faculty, respectively. Women averaged 41 publications, whereas men had approximately 66. In regard to race, faculty of color averaged 39 publications in comparison to almost 75 for white faculty. These differences may be confounded by differences in disciplinary affiliation by gender and race.

The next three items in Table 6 relate to service. These items reflect service at one's own institution, service to various professional organizations, and service at a broader, national level. While many significant differences for this variable can likely be attributed to a faculty member's rank (i.e. the longevity of their career), there are some distinctions to consider. For example, participants from health (.97) and social science (.89) disciplines were more likely to have service roles in their professional associations than were their colleagues in biology, chemistry or medicine. Respondents in health fields (1.60) were also more likely to have had service experiences in a broader, national advisory capacity.

Faculty members of color were less likely to have service experiences, compared to their white colleagues. There were significant differences in the means for service at the institutional level (.21), as well as with professional associations (.52) for faculty of color compared to their white colleagues (.49 and .81, respectively). The same was true for differences in regard to service experiences in a broader, national advisory capacity. Faculty of color had a mean score of .99 service experiences at the national level, while white faculty had a mean score of 1.32.

Men (.50) were somewhat more likely than women (.36) to engage in service at the institutional level, while women (.87) were significantly more likely than men (.70) to engage in service with professional associations. No significant differences were found for any of the types of service based on whether the respondents were from public or private institutions of higher education.

Correlation and regression analyses were performed to investigate the relationships between the independent and dependent variables. The results of these bivariate and multivariate analyses are presented in the next section.

Correlation Analyses

Table 7 presents the correlation coefficients between the dependent variables and all other analytic variables. The more relationships a respondent had with for-profit companies, the less concern there seemed to be about detrimental market impact. In addition, respondents with more funding from external sources were also less concerned about detrimental market impact. There was a negative relationship between detrimental market impact and the extent to which scientists think the process of obtaining funding interferes with the process of research. Respondents indicating more concern about detrimental market impact were least optimistic about the ease of acquiring funding for research. Conversely, participants with lower concern in regard to detrimental market impact were much more optimistic about future prospects for funding. Finally, there was a strong positive relationship between a participant's concern about detrimental market impact and the belief that the process of obtaining funding interferes with the

Table 7: Correlations of Dependent Variables, Independent and Demographic Variables. (N = 1554)

	Detrimental Market Impact	Detrimental Financial Focus
Connections to industry	-.095***	-.041
Access to funding	-.067**	-.079**
Interference of funding process	.356***	.198***
External salary dependence	-.058*	-.037
Scholarly productivity: Grants	-.059*	-.065*
Scholarly productivity: Journal articles	-.093***	-.028
Service: Institutional	-.051*	-.030
Service: Professional Associations	-.078**	-.028
Service: National Advisory Roles	-.037	-.029
Private Institution	-.043	-.034
Associate Professor	-.027	.001
Assistant Professor	.069**	-.021
Biology	.030	.042
Chemistry	.020	.035
Health	-.033	-.021
Social Science	-.008	-.040
Time since degree	-.038	.058*
Female	.009	.002
Minority	.062*	-.019

Significance Levels: *p<.05, **p<.01, ***p<.001.

progress of science. Respondents who were more concerned with the influence of the market were concerned about the extent to which seeking money for research gets in the way of the actual research, itself.

Analysis of scholarly productivity demonstrates that scholars who are more productive are less concerned about detrimental market impact. Researchers who served on more grants were less concerned about the market, while those with more peer-reviewed publications were less likely to be apprehensive about detrimental market impact on academic science. Findings were similar in regard to service experiences. Although there was not a significant relationship between service in a broad, national advisory capacity and concern about the influence of the market, there was a negative relationship between distress about market influence and institutional service, as well as a negative relationship between concern about market influence and service to professional associations. The more service experiences a participant had, the less he or she was concerned about the detrimental market impact academic research.

Assistant Professors expressed more concern about detrimental market influence than did their more senior counterparts, while faculty members of color were also more hesitant about market influence than were Caucasian faculty.

Perceptions of a detrimental financial focus of universities did not have as many significant correlations as concerns about detrimental market impact. Table 7 shows a significant negative relationship between the extent to which participants feel universities are too focused on financial aspect and their optimism about obtaining funding. As one might expect, the less optimistic participants feel about prospects for securing money for research, the more concern they have about the institutional focus on financially profitable research. In addition, there is a positive correlation between the perception that universities are too focused on money and that obtaining financial backing for research interferes with the forward progress of science.

There is a negative correlation between scholarly productivity in regard to grants and opinions about institutional financial focus. Scholars who have been lead investigators on more grants are less likely to think that universities are too concerned about money. There is, however, a positive correlation between time since degree and perceptions of institutional commitment to the pursuit of money. More senior faculty are more likely to believe that universities are too focused on financially profitable research.

Regression Analyses

Regression analyses were completed to investigate how the five independent variables are related to the dependent variables in the presence of the demographic variables. Standardized regression coefficients are presented in Table 8.

The first dependent variable, detrimental market impact, has a negative relationship with connections to industry. The more connections to industry a researcher has, the less concerned she is about the market's influence on research. Research cited earlier in this study suggested that this might be the case (Campbell et al., 2007b; Slaughter et al., 2004). Scholars with more journal articles were also less concerned about the influence of the market than were their less productive peers.

Two variables had significant, positive relationships with the dependent variable, concern about the impact of the market orientation of science. One is a participant's view of the challenges of obtaining funding. The more a researcher feels that the process of

Table 8: Standardized Regression Coefficients for Dependent Variables by Independent and Demographic Variables. (N = 1554)

	Detrimental market impact	Detrimental financial focus
Connections to industry	-.102***	-.025
Access to funding	-.031	-.070*
Interference of funding process	.351***	.199***
Percentage of salary from external sources	-.041	-.002
Scholarly productivity: Grants	-.010	-.109***
Scholarly productivity: Journal articles	-.073*	-.051
Service: Institutional	-.012	-.019
Service: Professional Associations	-.030	.003
Service: National Advisory Roles	.073**	.037
Private Institution	-.044	-.025
Associate Professor	-.037	-.028
Assistant Professor	.018	-.009
Biology	-.009	.008
Chemistry	.018	.023
Health	-.063	-.004
Social Science	-.041	-.040
Time since degree	. 058	.084
Female	-.021	-.021
Minority	.047	-.012
R^2	.158***	.071***

Significance Levels: *p<.05, **p<.01, ***p<.001.

obtaining funding interferes with the progress of science, the more likely he is to believe that the market has a detrimental impact. Finally, participants with service in national advisory capacities were slightly more likely to indicate detrimental market impact than were faculty members without
service in this capacity.

The second dependent variable, the extent to which participants believe universities are too focused on money, has significant relationships with three of the independent variables. There is a negative relationship between the extent to which researchers believe universities are focused on money and the ease with which they say funding is obtained. Faculty who believe it has become easier to get funding are less likely to indicate that they think institutions are too focused on securing funding, while faculty who think it has become harder to get money believe the opposite is true. There is a negative relationship between a researcher's perception of the university's focus on money and their scholarly productivity in regard to grants. The less likely a participant was to larger numbers of grants, the more she displayed concern about the university's focus on obtaining funding. The one significant and positive was in regard to the process of a scientist obtaining funding for research. Researchers who indicated that the process of obtaining funding interferes with the forward progress of research were likely to believe that academic institutions were too focused on money.

None of the demographic variables were significant in regard to either dependent variable. This means that sector of higher education, academic rank, academic discipline, time since degree, sex and race had no relationship to a researcher's impressions of the market orientation of academic science.

One independent variable had a significant relationship with both of the dependent variables. Participants' impression that the need to obtain funding interferes with the research process had a positive, significant relationship to both dependent variables. The more a participant felt the funding process interfered with research, the more concerned they were about the market orientation of academic research and the more concerned they were about the focus of the university on the financial aspects of research.

Conclusion

In closing, the research question is revisited: How do scientists' academic and professional experiences, including factors such as connections to industry, research productivity, perceptions of funding levels for science, appointment funding sources, and service experiences influence their perceptions of the market orientation of science? Different factors influenced each of the dependent variables. A respondent's perceptions of detrimental market impact were most influenced by connections to industry, the belief that the process of obtaining funding is more challenging than in the past, scholarly productivity in regard to journal publications, and service in a national-advisory capacity. A respondent's perceptions of the detrimental financial focus of universities were most influenced by the belief that obtaining funding is more challenging than in the past and that the process of obtaining funding interferes with academic work. Scholarly productivity in regard to grants also influenced a respondent's view of the detrimental financial focus of universities. No demographic variables were significantly related to either dependent variable.

CHAPTER 5: IMPLICATIONS

This study has examined connections between academic scientists' experiences and their perceptions of market influences. Specifically, this research is driven by the question: How do scientists' academic and professional experiences, including factors such as connections to industry, research productivity, perceptions of funding levels for science, appointment funding sources, and service experiences influence their perceptions of the market orientation of science? The focus in this study is on factors that influence a respondent's perception of the detrimental impact of the market, as well as factors that impact the extent to which respondents believe that academic institutions are too focused on financial gain. Five-thousand academic researchers in 500 departments at 50 major research universities were surveyed regarding the environments in which they conduct their scholarship.

The purpose of this study was to understand the extent to which factors related to the professional activities of academic scientists' influence their perceptions of the market orientation of scholarly research. It focuses on the impact of connections to industry (roles and products), opinions about the accessibility of funding, the funding source for a researcher's academic appointment, scholarly productivity (publications and grants), and scholarly service (institutional, professional, and advisory). The study examines how these factors influence two dependent variables: participants' perceptions of the detrimental impact of the market, and the detrimental financial focus of the universities.

Two independent variables are negatively associated with researchers' feeling concerned about the detrimental aspects of the market: connections to industry and journal publications. The more relationships a respondent has with industry, the less concerned she is about the negative impacts of the market. These connections with industry could be roles within private, for-profit businesses, or products or patents resulting from work with industry. Participants with more of these types of relationships with industry were less likely to express concern that market orientation has a negative impact on academic research. Additionally, the more scholarly publications a participant has, the less likely he is to think that the market is a detriment to academic research. The connection between increased scholarly productivity and less concern about the detrimental impact of the market, though true for journal publications, did not hold true for grants. Scholarly productivity in regard to involvement on grants is not related to a scientist's perceptions of the market orientation of science.

Two independent variables are positively related to researchers' belief that market orientation is, indeed, a detriment to science: challenges obtaining funding for research, and service in a national advisory capacity. Participants who believe that the process of obtaining funding interferes with the progress of science are more likely to say that market orientation is a detriment to academic research. This is also true for participants who serve in a national advisory role, such as a member of a review panel or study section, as a consultant to a non-profit, or as a member of a national advisory committee. These more senior respondents are more likely to agree that market orientation is detrimental to scientific research. This was the only type of professional service that had a significant relationship with participants' perceptions of the market orientation of academic research.

Concerning the financial focus of universities, two independent variables had significant relationships. Participants who say that the process of obtaining funding interferes with the progress of science are more likely to think that universities are too focused on obtaining money. Similarly, participants who think it has become harder to obtaining funding tend to believe that universities are too focused on the financial aspects of the research process. Finally, respondents with fewer grants are likely to believe that institutions are overly concerned with money.

Discussion

As research universities continue to embrace an innovation-driven, Triple Helix model of interaction among academic institutions, government and industry (Etzkowitz, 2003) it is important to assess how researchers view the impact of the market on academic research. The Triple Helix model highlights the importance of each of the three aforementioned institutions in order to "improve the conditions for innovation in a knowledge-based society," (Etzkowitz, 2003, p. 295). In this model,

> "Industry serves as the locus of production; government as the source of contractual relations that guarantee stable interactions and exchange; and the university as a source of new knowledge and technology," (p. 295).

This characterization of the role of academic institutions in the process of innovation helps inform how we conceptualize the work of academic researchers.

As the literature reviewed in this study demonstrates, market influences on higher education are pervasive (Slaughter & Rhoades, 2004; Slaughter & Leslie, 1997) and critical to the work being done at academic institutions (Kennedy, 2003). These relationships also provide serious challenges in regard to institutional mission, scholarly productivity, and research ethics (Bok, 2004; Stein, 2004; and Bero, 2007, for example). It is critical that the viewpoints of the scientists actively engaged in scholarly research are understood as institutions continue to encourage and manage partnerships with the private sector.

The results of this study demonstrate that the most important factors in determining a researcher's stance on the market orientation of academic research are: connections to industry, impressions about the ease of attaining funding, a sense that the process of obtaining funding impairs a faculty member's ability to do sound research, scholarly productivity in regard to publications and grants, and service in a national advisory capacity. Conversely, the percentage of a faculty member's salary that is obtained from outside the university did not significantly impact their impressions of the market orientation of academic research, nor did service in an institutional or disciplinary capacity, time since first PhD, faculty rank, academic discipline, sex, race, or the sector of higher education in which a participant worked.

Since data suggest that researchers with connections to industry are less concerned about the detrimental market impact on science than are researchers without, there appears to be a rift between academic haves and have-nots. Perhaps faculty without connections to the private sector are suspicious of the world of industry. Perhaps faculty with connections to the private sector are more familiar with the academy-industry relations and believe there is nothing to fear. Previous empirical research would suggest that the truth lies somewhere in the middle. Regardless, this particular difference in academic experience indicates an important distinction between opinions about the detrimental impact of the market on science.

This study suggests that one source for objective conversation about the topic of the market orientation of academic research might be faculty members who have served in national advisory capacities. While differences of perception based on ties to industry is not surprising, it was interesting to learn that service on national committees and consultancy to other larger-scale initiatives influenced a participant's impression of the challenges of relationships with industry. As previously mentioned, although discipline, time since degree and percentage of external funding did not impact a researcher's perception of the market's influence on science, this specific type of service was relevant.

Participants' responses about inequity in regard to funding, and the challenges the funding process present to actively engaging in research also paint a compelling picture of the environment in which academic science is being conducted. Institutional focus on the importance of financing research appears to create an environment that frustrates researchers who have been less successful in obtaining funding or are just more dissatisfied with the funding climate as a whole. These sentiments appear to be consistent across discipline, faculty rank, sex and race. Many faculty members are unsettled in regard to the challenges and realities related to funding their research. Perceptions that institutions are too focused on the financial aspects of academic research are strong.

In summary, academy-industry relationships are still a relatively new phenomenon. One in ten participants in this study had connections to industry, bit cross-sector connections are a growing phenomenon that cannot be ignored. Literature demonstrates that concerns are more pervasive and pressing than in the past (Campbell et al., 2007b; Kezar, 2004; Slaughter & Rhoades, 2004; Stein, 2004). This study demonstrates that levels of concern regarding the market orientation of academic research are tied to, among other things, a scientist's connections to industry and the perceived interference of the funding process in academic research.

Implications for Policy

In regard to institutional policies, this study builds on the qualitative work of Slaughter, et al. (2004) by presenting quantitative data demonstrating that academic scientists with connections to industry are less concerned about the market orientation of their research. In order to set appropriate policies for addressing academy-industry relationships, it is important that policy-makers understand the lens through which scientists view their work. This study demonstrates that academics with relationships to industry are much less concerned about the market orientation of scientific research than are researchers without similar connections.

Though empirical evidence (Bero et al., 2007; Campbell et al., 2007b; Campbell, 2006; Slaughter et al., 2004; Bekelman et al., 2003; Wazana, 2000; Campbell et al., 1998; Blumenthal et al., 1996a and 1996b; Cho & Bero, 1996) demonstrates no shortage of challenges as a result of academy-industry relationships, researchers may minimize or ignore these costs and problems. It is important for policy-makers to include guidelines or procedural steps that promote, e.g., the establishment of clear boundaries (Slaughter et al., 2004), and mitigate conflicts of interest (Campbell et al., 2007b). Policies that address, or attempt to avert, potential conflicts or misconduct may provide clearer, more successful working relationships for faculty as they enter into partnerships with industry.

To the extent that institutions can predict challenges between academic researchers and their partners in industry, undesirable situations may be preventable.

Faculty who serve at the national level seem to view the detrimental impact of the market orientation of science in a different way than do other faculty. Trying to understand the detrimental impact of the market orientation of science from the vantage of national leaders might provide important policy points at the institutional level.

The results of this study related to grants, ease of attaining funding, and institutional focus on financial matters demonstrate certain rifts between “haves” and “have-nots.” While it is not possible for institutions to regulate external grant monies, results of this study might suggest a need for efforts to provide more internal opportunities for funding to researchers who have not had as much success obtaining external grants. Policies that strive to create more balance in regard to access to research dollars may help create a more dynamic research culture and provide critical professional experiences to faculty who have not yet benefitted from these experiences. Access to internal research funds may help advance scholars’ careers as they look to forge connections in other arenas.

Implications for Practice

In regard to implications for practice, the results of this study demonstrate that offices at research universities that deal with the management of academy-industry relationships should not assume that their faculty are fully aware of the wide range of challenges that accompany partnerships with the private sector. This seems to be increasingly true as faculty become more academically productive and have more connections to industry. Training sessions at the beginning of a researcher's affiliation with offices managing AIRs might not be particularly effective. On-going connections to the practitioners administering the work done in concert with the private sector might help ensure that concerns are addressed as researcher's partnerships with industry continue to evolve.

Institutions and their offices that manage academy-industry relationships may also benefit from including a wide range of constituents in conversations about how AIRs should be administered. Though there may be similarities across disciplines and in regard to other demographic variables, it is clear that faculty with diverse experiences view the challenges of these relationships differently. Inviting faculty with a diverse range of experiences in regard to productivity and service into the conversation may help address the vast number of considerations that should be taken into account.

Limitations

One limitation of this study is the fact that it is based on scientists' own perceptions of academy-industry connections. As literature explored in this paper demonstrates, scientists tend to dismiss potential challenges posed by these relationships, minimizing or negating the possibilities of both logistical and moral quandaries (see, Slaughter et al., 2004; Campbell et al., 1998). Although literature is rife with examples and cautionary tales of risks posed by academy–industry relationships, there is still evidence that many practicing scientists do not share the same level of concern as some analysts (Slaughter, et al., 2004).

Another limitation of this study is that it simply asks participants to consider the impact of markets on academic science in the most general sense. Respondents did not assess positive aspects of academy-industry relationships, such as the practical benefits of research finding its way to the marketplace, or the financial gains returned to universities. Respondents did not assess specific challenges of these partnerships, such as the withholding of data or methodological details, inadequate research design, or the general stress of competition on research practices. As such, a participant's responses to the survey reflect their views of academy-industry relationships overall. An additional limitation of this study is that it only considers the presence or absence of academy-industry relationships, not the length of the connection or any differences based on area of the private sector with which a researcher is working. Finally, the survey only asks about participants' perceptions of academy-industry relationships, but it does not measure success or effectiveness of any actual relationships.

Directions for future research

A study that offers a more complete picture of both the positive and negative aspects of academy-industry partnerships and then measures participants' perceptions of the market orientation of academic research might yield more meaningful results. Assessing the extent to which respondents understand the complexity of academy-industry relationships, as well as any regulatory mechanisms already in place at their home institutions, could help researchers understand whether or not respondents are merely expressing their predispositions about these connections, or if they are well-versed in actual workings of these relationships.

Additionally, research on subjects with a range of experiences in regard to academy-industry relationships might provide useful data. Specifically, it would be interesting to know whether the benefits or challenges of relationships with for-profit entities differed by factors such as type of industry or the longevity of partnerships. Merely knowing whether or not respondents have connections to industry is not enough. A sample with a larger proportion of respondents who have participated in academy-industry relationships in a more diverse manner would provide meaningful insights. Looking more closely at various roles academics have held within industry, as well as the products resulting from these partnerships, will provide a better understanding of the perceptions and impacts academy-industry relationships have on scientists' views of the market orientation of academic research.

A particular, identifiable section of this sample that had significant concerns about the impact of the market orientation of academic science is the faculty members who have served in national advisory capacities. Participants with this particular type of academic service were much more likely to see the detrimental influence of the market orientation of science. Targeted inquiries with researchers with extensive experience on review panels, study sections, non-profit boards, advisory committees, and various governmental or non-profit consultancies might offer a broader understanding of why they think a market orientation is harmful to science. Interviews or surveys to understand the landscape of science from their perspective might provide useful information.

A content analysis of the policies of licensing offices and other entities at research universities that support partnerships with businesses might provide insight into how academy-industry relationships are planned for, structured and implemented.

Specifically, it would be beneficial to know to what extent faculty who enter into academy-industry relationships are being coached on potential challenges. Understanding the specific types of arrangements made in advance to negotiate the rights and rules for these partnerships would also be beneficial. The specificity of these policies and practices might offer insight into how academic institutions approach these partnerships.

A final direction for future research involves understanding whether the success of a researcher's partnership with industry influences their perception of the market orientation of science. Does a project that yielded successful results ease perceptions of the challenges of negotiating boundaries, communicating results or sharing profits? Does whether or not a partnership was financially or politically effective change a researcher's perception of academy-industry relationships and the market orientation of science?

The relevance and necessity partnerships between universities and industry are certain to be a lasting and increasingly ingrained aspect of research endeavors at universities in the United States. As the economic realities of institutions of higher education continue to be problematic and as the marketability of scientific research continues to grow, work done to clarify, legitimize and appropriately govern these relationships will maximize the advantages to both parties. The ability of faculty and institutional leaders to address challenges of academy-industry relationships, while simultaneously assuaging unfounded concerns, will strengthen the long-term viability of these evolving and critical partnerships.

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