VITA

Eric D. Motycka

EDUCATION

2011	Indiana State University, Terre Haute, Indiana Ph.D. in Educational Administration, Leadership in Higher Education
2006	Indiana State University, Terre Haute, Indiana Master of Business Administration, Finance concentration
2004	Burlington College, Burlington, Vermont Bachelor of Arts in Literature and Writing

PROFESSIONAL EXPERIENCE

2010-current	Indiana State University Foundation, Terre Haute, IN Director of Development Operations
2006-2010	Indiana State University/ISU Foundation, Terre Haute, IN Director of Development College of Technology
2005-2006	Indiana State University, Terre Haute, IN Graduate Assistant College of Business
2005-2006	Western Indiana Workforce Investment Board, Terre Haute, IN Financial and Statistical Analysis/Consultant
2002-2005	Atomized Powder Coatings, Terre Haute, IN Lab Manager
1999-2002	Hentzen Coatings Incorporated, Milwaukee, WI Production Manager/Formulator (Research and Development)
1997-1999	Sherwin Williams, Fort Wayne, IN Quality Control Technician

DEVELOPMENT OF AN INSTRUMENT TO MEASURE FACULTY

ADHERENCE TO THE NORMS OF SCIENCE

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Eric D. Motycka

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COMMITTEE MEMBERS

Committee Chair: Joshua Bryant Powers, Ph.D.

Professor, Educational Leadership, Bayh College of Education, and

Special Assistant to the Provost

Indiana State University

Committee Member: Marcia Miller, Ph.D.

Associate Dean, College of Health, Nursing, and Human Performance

Indiana State University

Committee Member: Bradley V. Balch, Ph.D.

Dean, Bayh College of Education, and

Professor of Educational Leadership

Indiana State University

ABSTRACT

The norms of science of *Communalism, Universalism, Disinterestedness,* and *Organized Skepticism* provide a framework for understanding and examining faculty activity related to the triple helix of university, industry, and government relations. Despite the increase in scholarship regarding faculty and the norms of science, there is a lack of research focused on measuring faculty adherence to the norms that is psychometrically valid and reliable. The goal of this dissertation was to contribute to the literature by developing and testing such an instrument. This instrument differentiates among the norms of *Organized Skepticism, Universalism, Commercialism,* and *Scientific Puritanism*, the latter two being refined labels that captured the questions involved with those scales. The instrument's psychometric properties demonstrated both construct validity and internal reliability via field testing with 290 faculty at United States Midwestern research universities.

DEDICATION

This dissertation is dedicated to Nupur and Krishaa, my wife and daughter, who have been the driving force behind its completion. To Nupur: for her support, understanding, and for picking up the slack at home while I toiled at completing this study. To Krishaa: for being as patient as a two year-old could be while her father asked for just a few more minutes so he could finish a sentence, paragraph, or table.

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CHAPTER 1

Introduction

In the 1940s, Jonas Salk's research at the University of Pittsburgh eradicated polio, a virus that would randomly kill and cripple scores of children each year (Kluger, 2006). Almost 40 years later in 1978, Ivor Royston, an associate professor at the University of California at San Diego, co-founded Hybritech. The company was the university's first start-up company built around Royston's patented and licensed monoclonal antibody technology that exhibited promising uses in the treatment of cancer (Jones, 2009).

By today's standards and reflected in the Hybritech story, one would expect that both Salk and the University of Pittsburgh would have seen the polio vaccine as a financial gold mine. But in contrast to Royston's commercialization of research and the many others like him who have pursued the path of entrepreneurism and commercialization, when Edward R. Murrow asked Salk who owned the patent to the polio vaccine, Salk famously replied, "Well . . . the people I would say. There is no patent. Could you patent the sun?" (Cohen, 2001, p. 34).

The juxtaposition of Salk and Royston fits into the broader context of faculty culture and how it has changed over the course of the mid-20th century to the early 21st century. Medieval universities carried the burden of transmitting knowledge from one generation to the next while providing training for a few professions. Universities in the 19th century leveraged basic research to become creators of new knowledge. Now, in the 20th and 21st centuries, universities have become the most important component of an integrated system of knowledge creation and distribution (Altbach, 2005b). Slaughter and Rhoades (2005) referred to an academic capitalist knowledge/learning regime that is typified by the increase in commercialization of colleges and universities. Slaughter and Rhoades framed their discussion within the context of the rise of the neo-liberal state where government provides support for individuals and corporations instead of overall social welfare. Although actors within the research university setting, notably within bio-science and engineering, have leveraged neo-liberal policies for entrepreneurial gain (Slaughter & Rhoades, 2005) within the new knowledge economy, this behavior is not restricted to bio-scientists and engineers. For example, university faculty and departments have had opportunities to leverage and manage copyrights gained through the academic capitalist knowledge/learning regime.

Altbach (2005a) and Slaughter and Rhoades (2005) illustrated contextual and economic shifts for colleges and universities in recent years. With those shifts have come changes in the way colleges, universities, and their faculty work and intersect within the new knowledge economy. It is this intersection with the new knowledge economy, a changing faculty culture, and the potential for a relaxation of the norms of science that concerns some scholars. Sztompka (2007) and Cook-Deegan (2007) investigated trust in science and how the openness of academic science adds to the scientific commons available for further research. Sztompka argued that a breakdown in the norms of science could erode trust in science and Cook-Deegan noted that a breakdown in the norms of science could reduce the flow of knowledge dissemination into the scientific commons where research findings are accessible at little or no cost. Both scholars investigated the potential for a change or shift in the norms of science in the broader faculty cultural context. Similarly, Altbach, referring to the structural changes within higher education, stipulated that the "changes will transform the research culture and the organization of research" (p. 300).

The *Chronicle of Higher Education* recently reported that, as part of his initiative to turn around the United States economy, President Obama's administration is exploring how universities can better perform as engines of economic development (Blumenstyk, 2010). On March 25, 2010, the Office of Science and Technology Policy and the National Economic Council released a request for information (RFI) on the commercialization of university research with the intent of gaining insight into best practices related to "fostering diffusion and commercialization of university research" (Commercialization of University Research Request for Information, 2010, p. 14,777). The RFI notice in the federal register opened with a reference to President Obama's national innovation strategy and stated, "Two key parts of this strategy are to increase support for both the fundamental research at our nation's universities and the effective commercialization of promising technologies" (p. 14,476). A few sentences later the RFI explained that "it is often transferring viable research discoveries to the marketplace that can pose the greatest challenge to innovators and entrepreneurs" (p. 14,476). The RFI specifically asked what policy and research funding changes the Obama administration should use in improving the transfer of research findings to successful commercialization.

To those familiar with the subject of university technology transfer, the process of commercializing university research through patent licensing, joint ventures, or spin-off companies, this initiative should not be a surprise. Etzkowitz, Webster, Gebhardt, and Terra (2000) explained,

> The emergence of the entrepreneurial university was a response to the increasing importance of knowledge in national and regional innovation systems and the recognition

> that the university is a cost effective and creative inventor and transfer agent of both knowledge and technology. (p. 314)

As a way of understanding the emergence of the entrepreneurial university in a knowledge economy, Etzkowitz et al. (2000) employed the triple-helix model of industry—university—government relations in which the university as a knowledge producer plays a larger role in industrial innovation (Etzkowitz & Leydesdorff, 1999). In viewing current events through the triple-helix model of industry—university—government relations, it could be said the Obama administration is fulfilling its role in working to implement fiscal and research policy that supports "research directed to the market, . . . technological innovation integrated to academic research, . . . [and] economic development" (p. 328).

While the Obama administration's approach embraces an overall societal benefit, it is seeking to leverage research commercialization processes and infrastructure that, as was mentioned earlier, have been suggested by Sztompka (2007) to upend the scientific ethos. Sztompka framed this argument with Ziman's outline of the transition from academic science which "began in the 17th century to post-academic science which occurred during the middle of the 20th century" (Ziman, 2000, pp. 28-31, 67-80). Sztompka stated that the norms of academic science are rooted in the prescribed four norms of science proposed by Merton (1973): Communalism, universalism, disinterestedness, and organized skepticism. Sztompka argued post-academic science was borne out of the need for external agencies and resources to fund more expensive research, privatization of research in which more findings are owned by sponsoring organizations, the commodification of science where scientific findings become a marketable item, the bureaucratization of science, and the "diminishing exclusiveness and autonomy of the scientific community" (pp. 218-219).

Problem Statement

The dividends received for the Obama administration's efforts to further leverage this structural change within academia could be significant if past financial results of some university technology transfer efforts are a predictor of future results. The 2007 Association of University Technology Managers (AUTM) licensing survey took a close look at university technology licensing, patenting, spin-off, and investment activity for 2007 when universities received over $48.8 billion in research and development (R&D) expenditures (AUTM, 2008). While 15,908 patent applications were made and 3,255 were actually issued, there were also 553 spin-off companies launched. The number of spin-off companies created since 1980 totaled 5,724, which equated to more than one company every two days. In 2008, there were 595 new companies formed as a result of technology transfer activity, 72% of which were started in the home states of the institutions from which they were spun-off (AUTM, 2009). Total sponsored research expenditures for 2008 equaled $51.47 billion. The reality is that, as more universities and colleges seek to leverage research commercialization, most institutions will fail to realize substantial net revenue generation from licensing activity (Turk-Bickakci & Brint, 2005). Powers and Campbell (2009) reported that in 2007 "77% of all revenues received by universities from technology licensing accrued to just 10 institutions" (p. 44). A majority of income distribution is concentrated with a few institutions and the costs of increasing the odds of a net return on R&D expenses are high. It takes at least $200 million in R&D expenditures to have a 50% chance of realizing a net return on technology transfer efforts. At $400 million the odds plateau at 65% regardless of additional R&D dollars spent. Despite the income distribution and investment required for increased odds of a return on investment, there are still large investments being made in support of technology transfer activity. Powers and Campbell concluded that technology transfer efforts should be used to maximize the odds of commercializing research, a benefit for the greater good, instead of maximizing revenue to the institution.

Powers and Campbell (2009) reported the financial realities and rewards of technology transfer and research commercialization and recommended a shift away from thinking of technology transfer in financial gain terms but rather thinking of the greater economic good. This would be accomplished by seeking to maximize the odds of commercializing the invention rather than seeking out the most lucrative licensing, join-venture, or spinout deal. The Obama administration, through the Office of Science and Technology's RFI, is seeking to leverage the research commercialization process and infrastructure for more focused economic growth and innovation which is in line with Powers and Campbell's conclusion.

The RFI also highlights current funding initiatives to the National Science Foundation's Partnership for Innovation program which funds projects "that will increase the engagement of faculty and students across all disciplines in the innovation and entrepreneurship process" (Commercialization of University Research Request for Information, 2010, p. 14,476). But per Sztompka's (2007) assertion, increasing faculty involvement in an entrepreneurship process that seeks to commercialize and privatize academic research potentially threatens to erode the scientific ethos and traditional norms of science. The RFI seeks to find ways to leverage the entrepreneurial behavior of universities and research faculty but does not request input on the scientific ethos and what impact new policies initiated through responses to this RFI might have on faculty and research culture and, in particular for this study, faculty adherence to the norms of science. While the scholarship has already quantified both the positive and negative financial and economic aspects of research commercialization (Powers & Campbell, 2009), there is little quantifiable evidence that increased research commercialization and academic entrepreneurship alters researcher attitudes toward the norms of science. The challenge, though, is that there are few developed instruments for measuring faculty attitudes and adherence to the norms of science, particularly ones that have received psychometric analyses. Without a valid and reliable instrument there is no method for achieving a baseline of the norms of science and any subsequent change to them because of research and funding policy. This study was among the first comprehensive attempts to address this challenge and to develop an instrument to measure faculty adherence to the norms of science and that is tested for its psychometric validity and reliability. Although there have been studies to capture the motivational behavior of entrepreneurial scientists (Standish-Kuon, 2007) through the lens of entrepreneurial cognition and how university incentives work into the equation (Renault, 2006), addressing faculty as the unit of analysis is not as common a theme in technology transfer literature. Wright, Birley, and Mosey (2004) have specifically stated that more research is needed to further understand the behavior of entrepreneurial faculty.

Pulling from social theory and in particular the norms of science as developed by Merton (1973), a stream of research focused on faculty engaged in entrepreneurial behavior has emerged (Anderson, 2000; Anderson, Martinson, & De Vries, 2007; Macfarlane & Cheng, 2008; Renault, 2006). This stream of literature has approached the phenomenon from the Mertonian scientific norm theoretical perspective and has illuminated gaps identified by both Anderson et al. (2007) and Macfarlane and Cheng (2008), who call for future inquiry that would include a greater number of normative principles and "a broader set of value statements" (Macfarlane & Cheng, 2008, p. 77). This previous scholarship has laid the foundation on which to develop a valid and reliable instrument for measuring faculty adherence to the norms of science.

Purpose

The purpose of this study was to address the challenge of accurately representing the norms of science in a set of value statements (Macfarlane & Cheng, 2008). This study pulled from classical measurement theory in developing an instrument to measure faculty adherence to the norms of science on a continuum that ranges from pure Mertonian (Merton, 1973) norms to pure Mitroff (Mitroff, 1974) counter-norms.

Some literature has illustrated and diagrammed the decision processes of faculty members engaged in entrepreneurial and commercializable research (Standish-Kuon, 2007). Other research hypothesizes subscription to norms of science to predict a scientist's level of engagement in commercializable research (Renault, 2006). There is, however, no instrument that empirically verifies through psychometric testing the attitudinal adherence to the Mertonian scientific norms of communism, universalism, disinterestedness, and organized skepticism (Merton, 1973) versus their counterparts of solitariness, particularism, interestedness, and organized dogmatism (Mitroff, 1974).

Importance of the Study

In furthering the scholarship on faculty researchers, this study is timely and relevant because it develops and validates an instrument that measures faculty adherence to particular norms of science. According to an extensive literature review of university entrepreneurship that covered 173 articles published between 1981 and 2005, 71% were descriptive in nature and not theory-driven (Rothaermel, Agung, & Jiang, 2007). As a unit of analysis the institutional level and the industry/university nexus have been well studied. Recent scholarship on trust in science (Sztompka, 2007) and ethics in research (Anderson et al., 2007; Anderson, Ronning, De Vries, & Martinson, 2010; Macfarlane & Cheng, 2008) have approached the study of faculty researchers through the scientific norm theoretical framework. In furthering this scholarship, a valid and reliable instrument for measuring faculty adherence to the norms of science is important as a tool for continued scholarship and study of ethical dilemmas in the sciences, trust of the scientific process, and the measured impact of increased research commercialization on faculty culture and faculty adherence to the norms of science.

CHAPTER 2

Review of the Literature

This chapter provides a review of the literature concerning the historical development of the role of faculty, the notion of social control and why and how it developed as a means of guiding faculty behavior, the norms and counter-norms of science, technology transfer in higher education, and finally what has been learned through previous efforts at developing instruments and scales that measure these norms. This latter discussion will evidence the gap in scholarship that necessitates further work in this arena.

Collegiate Faculty in Historical Context

Colonial period through Civil War. Boyer's (1990) germinal scholarship on the historical and changing role of the professoriate articulated the role of faculty over time and into the present. Beginning with a recap of three overlapping phases of scholarship within American higher education, Boyer stated that colonial colleges focused on the students and on building character. The goal was to prepare "new generations of civic and religious leadership" (Boyer, 1990, p. 3). At this time, teaching was viewed as a calling, something sacred. This centrality of the teaching role for faculty carried well into the 19^{th} century.

"The American college was conceived of as a social investment" (Rudolph, 1990, p. 58). Throughout the 19^{th} century, this investment turned from one focused on the building of young men to nation building (Boyer, 1990). Reform was in the air and a strong push was made toward education that was more readily applicable to the needs of a growing nation than an education in the classics that held to a strict and unwavering curriculum. Perhaps the University of Virginia is the best example of this movement toward a free and liberating education that included studies in medicine, mathematics, law, and moral philosophy (Rudolph, 1990). Thomas Jefferson guided the Virginia Board of Commissioners in 1818 and the Board of Visitors put his plan into place in 1824. The great change was that the student could choose his own course of study. The University of Virginia's genius was "its avoidance of superficiality and compulsion, the two evils which finally undermined the classical course of study" (Rudolph, 1990, p. 127) and ushered in the elective system.

Nineteenth century reforms to the American college and university did not happen without resistance. The Yale Report of 1828 encapsulated a strong sentiment toward classical education and the Aristotelian method of teaching (Rudolph, 1990, p. 131). In looking to define classical education and make a case for its importance, the Yale Report was so strong in its impact that it molded the American college and university for the next century. Yale and Princeton, both advocates for "combating the subversive tendency of the new subjects, and in fighting off principles of option and election" (Rudolph, 1990, p. 131) sent young graduates to the South and West to found colleges. These colleges, like Beloit College in 1849, built their courses of study on the Yale Report. Within the Yale Report was a core philosophy that viewed the mind as a vessel and a muscle that could be trained. In order to balance the mind it was necessary to discipline it and shape it toward reason and balance. The mathematics and classics were the prescription within the Yale Report. Mathematics shaped the mind as a tool for reason and the classics balanced the mind by directing and molding tastes. The Yale Report was effective in assuring the curriculum would not substantially change until after the Civil War.

Post Civil War. Despite the Yale Report's strong powers of suasion, by 1851 the commitment to practical education could be said to have reached a zenith in the planning for the opening of the Massachusetts Institute of Technology. Another example of the trend toward applied education is the output of the 1851 University of North Carolina faculty delegation that toured science and technical programs in Rhode Island, Massachusetts, New York, and Connecticut. Two years later a college of applied science opened at the University of North Carolina (Thelin, 2004). To completely open the door to applied education it took an act of legislation, the Morrill Act of 1862 (Thelin, 2004). The resources generated from the sale of federal land given to states through the grant would go to fund both education in the liberal arts and training in agriculture and the mechanical arts (Boyer, 1990). Education had become something to serve the common good and thus American higher education had added service to the nation to its repertoire. The Morrill Act has been considered the beginning of an education of democracy—affordable and practical education offered by state colleges and universities (Thelin, 2004). Applied education had taken root through the Morrill Act, and research in both agricultural and mechanical studies were represented by the middle of the 19th century at both Harvard's Lawrence Scientific School and Yale's Sheffield Scientific School (Boyer, 1990).

The rise of the research university model and professionalization of faculty. By the late 19th century American higher education began to model itself after German universities and began conferring the degree of Doctor of Philosophy. Academics moved toward a reliance on the rationality of science. Based on the German model of free inquiry and the generation of new knowledge, basic research agendas began to take hold in American higher education (Boyer, 1990). Whereas in the late 19th century research and graduate education was the exception rather than the rule, the 1940s brought change to the higher education climate in America. World War

II prompted the creation of the National Defense Research Committee, which later became the Office of Scientific Research and Development. American higher education and the government had pulled together for a common cause, to win the war, and the academic revolution created a new climate in which faculty became aligned with disciplined-based departments. This alliance also had a direct effect on the public attitude toward science and societal welfare. It was the Manhattan Project's ability to discover a weapon of unprecedented destructive power that led to the perception that large-scale science could have benefits for society (Mowery, Nelson, Sampat, & Ziedonis, 2004). The changing climate ultimately led to faculty being primarily evaluated as researchers instead of teachers (Boyer, 1990).

The faculty researcher within the scientific disciplines could be defined as professionals, but this professionalization process had been taking place since the middle of the 19th century and culminated in the establishment of the American Association of University Professors. A number of learned societies sprung up during the 19th century (Rudolph, 1990). The first was in the American Philological Society in 1869. The American Chemical Society followed in 1877, then the Modern Language Association in 1883, the American Historical Association in 1884, and the American Economic Association in 1885. Among other things, at annual meetings they discussed papers, formalized and standardized their disciplines, and most importantly the meetings manifested how the distance between scientists had shrunk by bringing together specialists who essentially had their own language. The associations and their annual meetings instilled a sense of belonging (Rudolph, 1990).

Many decades prior to World War II, academicians had come to respect the process of scholarship. Along with this respect for scholarship came an adherence to the tenets of academic freedom, especially as it pertained to the scientific point of view as being essential to rooting out ignorance (Rudolph, 1990). As an example, the discoveries of Charles Darwin often conflicted with sectarian interests, but in the end the science prevailed over the complaints. Academic freedom came to mean that professors were comfortable with a changing truth. The professor had a right to freedom of enquiry and freedom of teaching as well as the right to report his or her findings in an environment that held to the scientific viewpoint. Academic tenure came to be added to the concepts of academic freedom during the early years of the 20th century. Tenure provided not only academic freedom but also a way to safeguard the professor and his or her work. The professoriate had become professionalized and in 1915 the American Association of University Professors was established to develop and protect the standards of academic freedom and tenure. "Its establishment symbolized the arrival of the academic man [sic] in America" (Rudolph, 1990, p. 415).

Post World-War II through 1980. During World War II the Office of Scientific Research and Development (OSRD), headed by Vannevar Bush, entered into research agreements with universities and industry. MIT received the most contracts, 75 in all, for a total of $866 million in 1996 dollars (Mowery et al., 2004). The OSRD was responsible for transforming the scale to which the federal government funded university research. As stated in Mowery et al. (2004), Bush's 1945 report on postwar federal science policy, *Science: The Endless Frontier*, stated specifically that because basic research was the greatest source for economic growth a single agency should be created to manage all basic research funding. While Bush's proposal was never put into action, the military and the National Institute of Health (NIH) assumed the role of supporting basic and applied research.

Research funding at American universities grew at an unprecedented rate and cemented the research university model into place. As an enterprise, academic research funding increased almost six times in constant dollars from 1935 to 1960. It more than doubled from 1960 to 1965 Mowery et al., 2004). In 1958, the launch of the Russian satellite Sputnik led to increased federal funding for graduate education and facilities. The goal was to increase the pool of research talent and to ensure the equipment and facilities were adequate for high-quality research.

While the rate of research funding accelerated and Bush's vision had finally been implemented in 1950 as the National Science Foundation, defense and public health research have taken the bulk of federal research dollars. The expectation was that the research would generate "practical benefits" (Mowery et al., 2004, p. 24) for the missions of federal agencies. As an example, the Department of Defense, the National Aeronautics and Space Administration, and the Atomic Energy Commission accounted for over 80% of federally funded academic research in 1954. The National Institute of Health (NIH) also expanded its share of federal funding. From 1953 to 1960, the NIH accounted for one-third of federal research funding, but by the early 21st century NIH funding accounted for more than 60% of federal funding of university research. This strong link between basic research funding and federal funding of biomedical research has contributed greatly to the rapid expansion of biomedical innovation, pharmaceutical innovation, and medical devices (Mowery et al., 2004). Another factor leading to the eventual boom of biotechnology was the Supreme Court's 1980 decision in *Diamond v. Chakrabarty* (Mowery, 2005). In the case a broad patent was upheld that allowed the patenting of molecules, organisms, and research techniques that originate from the biotechnology field of research.

As was stated earlier, the reasoning behind federal funding was to generate discoveries that could be applied to agency missions (Mowery et al., 2004). However, until 1980, only a handful of universities were actively engaged in patenting activity, preferring instead to disseminate research through the traditional and freely accessibly publication and scholarly presentation process. Senators Bayh (D-Indiana) and Dole (R-Kansas) in 1978 felt that this limited use of patents hindered the diffusion of innovations into the marketplace and hence they introduced a bill to allow universities and small companies to own the patents of inventions made through federally-funded research (Bayh-Dole Act, 1980). It was also argued by witnesses supporting the bill that government-funded patents experienced higher rates of utilization if the patents were held by the contractor rather than the granting agency. Another statistic cited was that in 1975 only 5% of 28,000 patents owned by the federal government were actually licensed. "The system and policy at the time was argued to be inefficient and through giving patents rights to contractors incentives would be created to develop and commercialize" (Mowery et al., 2004, p. 90). The Bayh-Dole Act, discussed at length in a later section of this chapter, was passed during the winter of 1980 and signed into law by President Jimmy Carter in December of that year.

Entrepreneurial university era post 1980. By the mid-20th century research had been added to teaching and service as one of the three core roles of faculty in American higher education. To highlight the prominence of research in the evaluation process, Boyer (1990) cited two national surveys conducted by the Carnegie Foundation for the Advancement of Teaching. In 1969, 21% of faculty surveyed strongly agreed that tenure would be difficult to achieve without publishing. By 1989 this number had increased to 42%. Although teaching, research, and service are rarely rated the same during the evaluation process (Boyer, 1990), they are commonly referred to in identifying the role of faculty.

American higher education had gone from preparing civic minded individuals and religious leaders during the colonial period to pushing the frontiers of knowledge through basic research in the 20th century. By the late 20th century and early 21st century American higher education had become the most important component in a complex system of knowledge creation and dissemination (Altbach, 2005b). Furthermore, American higher education had come to be viewed as a vehicle for entrepreneurism, innovation, and economic development (Blumenstyk, 2010; Etzkowitz & Leydesdorff, 1999; Etzkowitz et al., 2000).

Social Control and Faculty

While a stronger emphasis on American higher education's research output and its ability to positively impact the economy emerged, a concern grew about the science community's ability to govern itself (Braxton, 1999). In other words, there existed the opportunity for scientists to destroy the public trust placed in the scientific community. Fanelli (2009) pointed to scientists faking stem-cell lines or using duplicated graphs in scholarly journals as examples of scientific misconduct that erodes the image of a scientist as an objective seeker of truth. Social control theory (Goode, 1957) constitutes frameworks on which some of this misconduct scholarship has been built.

Social control theory posits that professionals of any kind are a community of professionals within the larger community (Goode, 1957). They operate as a community within a community. As a community of experts they are afforded many powers and privileges because the lay community cannot adequately judge the merit of the professional's work. The professionals opt not to exploit their privileged position because by doing so they would lower their prestige and position and the lay community would levy stricter social constraints. In sum, the concept of social control refers to the lay community's ability to levy controls or constraints on a professional community (Goode, 1957).

Braxton's (1999) edited collection presented the scholarship of misconduct in science through historical overviews, theoretical perspectives, policy and law perspectives, and empirical treatments. While Braxton's edited work covered a number of items, the focus for this dissertation will be the theoretical perspective of social control.

Braxton's (1999) edited volume highlighted that the lay public imposed social controls on the scientific community for a number of reasons and through a number of venues. A few of the reasons behind imposing social controls on the scientific community are as follows: science's increasing expense and visibility, was seen as a resource for power, and considered a base of intellectual authority, legitimacy, and prestige, and was held in high esteem, much like religion (Braxton, 1999). The lay public levied regulatory mechanisms through government means such as the National Science Foundation and the U.S. Department of Health and Human Services (Braxton, 1999). But also, "society had obtained an indirect social control by yielding direct social control to the professional community, which thus can make judgments according to its own norms" (Braxton, 1999, p. 198). Braxton (1986) echoed Goode's (1957) reference to a profession's norms and stated the norms of science were "of special importance as mechanisms of informal social control" (p. 311). With that as context, the following section of this literature review covers the norms of science as they were introduced by Merton (1973) and the counter-norms of science introduced by Mitroff (1974).

The Norms of Science

Mertonian scientific norms. This section of the review of the literature presents the four scientific norms of communism (communalism), universalism, disinterestedness, and organized skepticism as they were described by Merton (1973). Based on Barber's recommendations (as cited in Braxton, 1986), the term *communalism* is used in place of *communism* in light of the latter's negative connotation.

Communalism. The norm of communalism calls for all scientific findings to be made public and shared with the scientific community (Braxton, 1986). Secrecy is not an option under this norm. As Merton (1974) stated, because scientific findings are products of collaboration the findings should belong to the community. This could apply to any scientific finding from Salk's polio vaccine to a process for the production of monoclonal antibodies. In adhering to the norm of communalism, one could state that both discoveries should have been freely available to the community at large. Where this norm could cause confusion or dissonance within the academic community relates to research discoveries made through funding from private industry. Under some contract agreements it might be required of the researcher that he or she delays publishing research findings in academic journals (Mowery, 2005). It could be possible for the researcher to be barred from publishing any of the findings. This could be seen to go against the norm of communalism.

Universalism. The norm of universalism within science reflects upon the criteria by which scholarship and research findings are judged (Merton, 1974). Universalism postulates that the scientific community should judge scholarship and research findings based on the merits of the scholarship, not the identity of the scholar. The criteria by which scholarship is judged should be universal and pre-established and are most obviously manifest in the process of blind peer review for scholarly publication. Within this framework, who a scholar is does not advantage her or him over another researcher, rather the quality of the work provides the differentiation. What this norm further stipulates is that no researcher should be judged based on socio-economic background, gender, religion, race, ethnicity, or any other differentiating characteristic other than the merits of his or her research. Andersen (2001) investigated the norm of universalism in Dutch scientists to determine adherence to the norm of universalism with regard to class origin. Based on a survey of 788 Danish scientists, Andersen confirmed that there is a strong class bias in researcher recruitment as well as a bias in recruitment based on gender. Class bias was the strongest bias between the two. Andersen concluded "the bias cannot be attributed solely a violation of the norm of universalism because the variables producing the disparities in recruitment and career attainment are not verified" (p. 271).

Disinterestedness. In the simplest terms possible, disinterestedness is "the preference for the advancement of knowledge as opposed to the individual motives of the scientist" (Braxton, 1986, p. 312). In adhering to this norm a scientist should be less concerned with future grant funding than the actual knowledge produced by the research. The same could be said for a scientist performing a scholarly study for private industry. The personal interest in the outcome of the study, based on disinterestedness, should be solely for what the findings will add to the body of knowledge, not any personal reward. Macfarlane and Cheng (2008), as illustrated in Appendix A, addressed this norm directly by asking in their survey if researchers aligned their research with funding opportunities. The flip side to aligning research with funding opportunities would be to first express the interest, define the problem, background literature, and method of answering the research question, and then seek funding if necessary to complete the study.

Organized skepticism. Organized skepticism stipulates that all scientific findings should be reviewed for scientific merit before being accepted as new knowledge or true scientific findings. All findings, based on this norm, should be submitted to rigorous review. All scientists, even the scientist performing the research (Merton, 1973), should approach all findings with a degree of skepticism. Based on the scientific method and the norms of scholarly conduct, especially as they were espoused by the German research model, truth should be expected (Rudolph, 1990). With that view in mind, it would be necessary to view any finding with a degree of skepticism, even one's own findings. The process by which research is presented and then others attempt to replicate or refute the work is the archetypical example of organized skepticism.

Mitroff counter-norms. Through a series of interviews with 42 prominent lunar rock scientists conducted over the three-and-a-half year period begun three months after the Apollo 11 lunar landing, Mitroff (1974) identified a set of alternative or counter-norms to Merton's four norms of science. Mitroff stated that Merton had moved from a stance in 1949 of conceiving a dominant set of scientific norms to, in 1963 when Merton wrote about sociological ambivalence, seeing that science actually possessed a set of conflicting norms. Merton (1968) and others had attempted to put a name to a dominant set of norms but they only were able to accomplish half the task (Hagstrom, Storer, & Barber, as cited in Mitroff, 1974). Mitroff set out to codify the other half of the scientific norms, not to test if one set of norms was superior to the other but rather equal in use. Mitroff found that neither set of norms was dominant in all situations. What he found was that the more complex or ill-defined the hypothesis the less clear cut the solution and the less traditional Mertonian scientific norms would be employed. What follows are the four counter-norms and how they are defined.

Solitariness. In being the counter-norm to communalism, solitariness calls for secrecy as a necessary behavior among researchers because property rights also include protective rights over one's findings. In this regard, all scientific findings belong, in some manner, to the discovering scientist, not the community at large (Mitroff, 1974). An example of this norm is reflected by referring back to the opening paragraphs of this study. Jonas Salk exhibited behavior consistent with the norm of communalism while Ivor Royston exhibited behavior consistent with the norm of solitariness. Another way of conceptualizing the norm of solitariness is the propensity for a faculty researcher to view his or her findings as personal property thereby providing him or her with a right to ownership of the patent and any licensing revenue generated. Recently faculty inventors have been exerting their right to ownership of their inventions. The driving force behind this is best exhibited in the Inventor's Bill of Rights (Collins, 2010) unveiled at the AUTM's annual meeting in March 2010. The argument is that the Bayh-Dole Act afforded patent rights to universities and contracted companies at the expense of faculty and graduate student inventors.

Particularism. In contrast to universalism, particularism embodies the norm of accepting or rejecting scientific findings based on who is making the scientific claim (Mitroff, 1974). In this regard, the scholarship of one researcher could be viewed as having more merit simply because of the reputation of the scholar who made the scientific finding or discovery. This norm can be seen in the outcome of what Merton and Sztompka (1996) referred to as the Matthew Effect. The Matthew Effect hypothesizes that scientists who have made their marks in the professional academic world will tend to receive more credit—an inordinate amount of credit—than their lesser known peers who are making equal or greater contributions to the body of knowledge. Whereas Andersen (2001) studied universalism with relation to socio-economic background and recruitment into the sciences, the Matthew Effect points to another form of particularism, or anti-universalism, and that is the blanket acceptance of a finding based on the scientist, not on the merits of the work. Who said something, because of the Matthew Effect, can have more importance than what is said and how the conclusion was derived.

Interestedness. In contrast to disinterestedness, a scholar who shows a personal interest in the outcome of the research would care more about the outcome and his or her personal satisfaction and reputation from the finding than in the actual addition to the body of knowledge (Mitroff, 1974). Interestedness should necessarily be construed as a de facto interest in financial reward. In understanding interestedness it is helpful to imagine a hypothetical situation whereby a scientist builds his or her research agenda based on funding opportunities offered by NSF, NIH, or a private corporation. The researcher would be interested in the funding more than the research and would allow funding policy to drive his or her research agenda. The flip side of this would be a researcher who builds his or her research agenda based on the desire to answer a research question posed by the rigors of scholarship, regardless of what the answer might be. Arriving at a specific conclusion is of no interest, it is getting to the underlying truth that matters most.

Organized dogmatism. While skepticism identifies a scientist as being skeptical of even his or her own findings, dogmatism identifies a scientist who would be skeptical of all other findings but his or her own. He or she would be sure to deeply understand the shortcomings of a predecessor's finding so when his or her findings are invalidated the scientist can point to earlier research as the reason for his or her own failure (Mitroff, 1974). In further understanding the norm of organized dogmatism, it is necessary to look briefly at Mitroff's (1974) findings. During Mitroff's interviews one respondent said,

> The severest test of an idea occurs when you've done everything in your power to make the best possible case for it and it still doesn't hold water. . . . This doesn't mean you don't discard your ideas. You do, but with reluctance. (p. 591)

Organized dogmatism can also be viewed as a bias toward your own ideas and discoveries, a bias that gives the scientist the emotional attachment to plug along when he or she meets with adversity. To further illustrate one participant's perception of dogmatism and partiality, "I can't recall any scientist I've ever known who has made a fundamental contribution that was impartial to his discoveries or his ideas" (Mitroff, 1974, p. 591).

University Technology Transfer

To this point in the literature review, the evolution of the faculty role in higher education, how society has sought to manage or influence the behavior of scientists, and finally the norms and counter-norms of science were discussed. In this section of the review, the emergence of the entrepreneurial university and the practice of proprietary science through university technology transfer—the growing mechanism by which university research is developed, transferred to industry, and developed into bona fide products for sale—is discussed. This body of research helps frame why counter-norms have increased as a focus of faculty work and, in a period of resource contraction, why institutions have been keen to pursue such activities with considerable enthusiasm.

There have been many theories and arguments put forth for why universities have engaged in the process of research commercialization. One is resource dependence theory, which views organizations "as coalitions, altering their structure and patterns of behavior to acquire and maintain needed external resources" (Ulrich & Barney, 1984, p. 472). When a source of revenue begins to go away, like state appropriations for public universities, those universities will search for alternate sources of revenue (Cheslock & Gianneschi, 2008; Powers, 2003), such as through technology transfer. Other literature has investigated the Bayh-Dole Act of 1980 as an influencer of institutional and faculty behavior through the incentification of patenting and licensing rather than the traditional dissemination route of scholarly presentation and publication (Mowery, 2005; Mowery et al., 2004).

Regardless of the rationales for the rise in technology transfer, with the perception that considerable revenue opportunity is at stake through the intellectual capital of faculty, there are strong efforts to find ways to more effectively manage the commercialization of inventions discovered through university research (Commercialization of University Research Request for Information, 2010; Markman, Phan, Balkin, & Gianiodis, 2005). At the same time research universities are being challenged to become more efficient innovation engines and economic development machines (Blumenstyk, 2010).

The process of commercializing faculty inventions or products involves many decisions (Standish-Kuon, 2007) and many internal and external stakeholders (Boni & Emerson, 2005). Depending on whether the end result desired is revenue generation or economic development (Golob, 2006), commercialization can generally take place in many different forms. The process of university technology transfer commercializes faculty inventions by first patenting the invention and then searching for a suitable license agreement. The patent is in place to afford rights to the both the patent holder, in this case the university and the faculty members involved, and the entity that eventually licenses the patent. Licensing allows the license holder to take the invention to market while paying a royalty to the university. If a suitable license agreement cannot be found and the university has evidence that the invention will provide a strong enough return on investment, the university might choose to create a separate company for commercialization of the invention. This new company would be referred to as a spin-off company. There are many ways to commercialize a university invention and research has shown that while some universities are successful at leveraging commercialization activity for substantial profit many fail to do so; there is no strong evidence that supports an actual return on investment (Siegel & Phan, 2005). A failure to realize a return on commercialization activity investment can have many causes ranging from a low level of industry and university collaboration (Turk-Bickakci & Brint, 2005), to poor research quantity and quality (DeVol et al., 2006), to the enormous risks and long timeframes involved in the development of basic technologies for practical application (Heher, 2006). Regardless of the potential impediments to financial success, many universities and colleges are and will continue working toward effective commercialization agendas (Heher, 2006).

This portion of the literature review reviews technology transfer scholarship in two areas as a frame on the issues impacting faculty norms of science. The first area is the arena of resource generation and technology transfer and the second is the impact of the Bayh-Dole Act.

Resource generation and technology transfer. Financial resources for United States higher education come in many forms: state appropriations, federal funding, and private sources such as industry. Powers (2003) showed that state appropriations had a negative effect concerning licensing income generated from university technology commercialization. When state appropriations are high, the university does not have to generate as much external funding, but when appropriations are low, the university will seek out different sources. Technology commercialization is one of those sources and viewed as valuable not only to the general university, but as a source of funds for further growing the research enterprise, critical to enhancing a research university's prestige and perceived ability to contribute to economic development. Heher (2006) stated that without a substantially funded research base and strong research culture, a technology commercialization initiative will have little chance of producing a positive return. Without the pipeline of disclosures, the attempt to generate revenue or develop the economy will not be successful.

Technology transfer, “the process of transferring scientific findings from one organization to another for the purpose of further development and commercialization” (AUTM, 2008), is extant at a number of colleges and universities across the United States. Some universities like the University of Florida have reaped strong financial rewards (Grassmuc, 1991; “U. of Florida Gulps Gatorade Profits,” 2002) from commercializing Gatorade. As the subject of university technology transfer has received much attention since the early 1980s so too have the number of universities participating in the enterprise increased (Mowery et al., 2004). This growth in university technology patenting and licensing has been seen most notably in the fields of biomedical sciences and engineering. As previously introduced a major challenge facing the continued growth of university licensing and patenting is the creation of policies that ensure innovations made possible by public funds will have the “greatest societal benefit” (Mowery et al., 2004, p. 2). It is a great challenge, and one that belongs to the universities alone:

> The responsibility for managing patenting and licensing in a fashion that preserves the integrity of higher education and maintains political support for the large public research budgets that have been devoted to U.S. universities’ research activities since 1940 rests with universities. (Mowery et al., 2004, p. 189)

Not all universities are equally successful. In 2003, the top 10 universities accounted for almost one-third of all patents issued to universities while nearly half of all licensing income went to those same schools (DeVol et al., 2006). Making that top list are schools like New York

University (NYU), Stanford University, the University of Florida, and the Massachusetts Institute of Technology (MIT). The differences in licensing income can be large. NYU's cumulative earnings from 2004 to 2006 were $400,023,414 and in 2006 NYU alone earned $157,412,824 in licensing income (AUTM, 2008). This is not the norm. Dartmouth College, in 2006, only earned $3,282,958. Portland State University, while spending a little over $40 million in R&D in 2006, earned zero dollars in 2006 and cumulatively from 2004 to 2006. Because of the popular successes of technology transfer, which are exceptions, exaggerated expectations for new technology transfer initiatives within a university can set the new initiative up for disappointing returns in the future (Heher, 2006).

Bayh-Dole Act of 1980. The fact that university innovation is sometimes patented and/or licensed to industry is not a new phenomenon (Mowery, 2005; Mowery et al., 2004). Although a few universities were engaged in patenting and licensing technologies in the early to middle part of the 20^{th} century, the modern era of enormous expansion can be traced to one piece of federal legislation: the Bayh-Dole Act of 1980. As mentioned previously, Bayh and Dole argued that patents on inventions made possible through federal funding should be owned by the contractor not the sponsoring federal agency. It was argued that more efficient use would be made of these inventions if they were owned and licensed by the contractor (Mowery et al., 2004). Contractor ownership as well would incentivize the commercialization of inventions, thereby increasing the societal benefit of federally-funded research.

In his study of the history and political environment surrounding the creation of the Bayh-Dole Act, Mowery (2005) found that it was university reaction to a comment in 1977 by the Health, Education, and Welfare Office of the General Counsel that stated university patents and licenses, especially exclusive licenses, could drive up the cost of health care. It was then a request by a Purdue University patent officer and a congressional staffer to Senators Dole and Bayh that led to the drafting of the University and Small Business Patent Act. Many other universities including Harvard, Stanford, MIT, and the University of California lobbied for passage of the bill. In conjunction with the Bayh-Dole Act of 1980 are two other important events that shifted the United States to stronger patent protection policies. The first was the 1980 Supreme Court decision in *Diamond v Chakrabarty* that broadened the scope of what could be patented in the biotechnology industry (Mowery, 2005). Following soon after was the establishment of the Court of Appeals for the Federal Circuit in 1982 that was to serve as the final appeal for patent cases (Mowery, 2005).

The Bayh-Dole Act is the undisputed catalyst that provided opportunities for universities to own, patent, and license inventions (Dai, Popp, & Bretschneider, 2005) made possible through federal grants. Its passage opened the door behind which numerous universities and faculty entrepreneurs were waiting. While the Bayh-Dole Act was the catalyst for creating the current U.S. environment, it also was accompanied by other pieces of a complex puzzle that leveraged the unique characteristics of the U.S. university. This is extremely important to understand especially in light of post Bayh-Dole university contextual circumstances and both federal and state policy developments. Furthermore, it would be a mistake for policy makers wishing to expand university technology transfer activity in the international arena to think a single legislative act upholding the rights of universities to own its inventions could alone promote university technology transfer and single-handedly drive economic and industrial innovation (Mowery et al., 2004). Mowery (2005) stated it best, “Growth in both university patenting and licensing predates Bayh-Dole and is rooted in unique characteristics of the U.S. higher education system” (p. 56). Mowery’s analysis related to nation-specific characteristics was buttressed by

Baldini's (2009) research on the Italian higher education research enterprise, where there are many obstacles to efficient commercialization including a lack of TTOs, lack of funding for patent applications, teaching and administrative loads that are too heavy, and, among other challenges, cultural problems.

For the American research university the Bayh-Dole Act of 1980 paved the way for academic entrepreneurs and universities to reap the rewards of their federally funded discoveries and to increase their patenting activity. The Bayh-Dole Act's intent was to make it easier for universities to own patents to their discoveries and to license those patents. One study in particular showed that this intent has been met. In a study examining growth during the 1990s in a three-stage process of commercializing university inventions, Thursby and Thursby (2002) found increases in all three stages of the process—disclosing discoveries, patenting discoveries, and licensing the patents. During the study period of 1994 to 1998 Thursby and Thursby found that disclosures increased at 2.7% annually. The study examined concerns that patenting activity might erode the amount of resources and faculty time spent on basic research. The study found that from 1977 to 1980 the average proportion of research expenditure allocated to basic research was 0.67 while for 1994 to 1998 it was .665. This indicated a negligible to non-existent shift in university research agendas. The greatest jump was in patents, which experienced a 12.1% annual growth. The authors attributed this change to the entrepreneurial behavior of administrators rather than a change in faculty research agendas.

Faculty, Technology Transfer Activity, and the Norms of Science

As discussed above, the pressures for the pursuit of technology transfer are substantive and have helped to influence how administrators and faculty think about the nature of knowledge and its dissemination. Yet, although perceptions of opportunity for fame, fortune, and freedom play a large role in motivating university researchers, universities are not necessarily places where fortunes can be made (Graff, Heiman, & Zilberman, 2002). So what drives faculty researchers and, in particular, those engaged in academic capitalism? Renault (2006) stated that researchers fell along a continuum from pure Mertonian thought to the new norm of academic capitalism. Through a combination of in-depth interviews with full-time biotechnology and information technology faculty and a web survey administered to 420 faculty at 12 different universities, Renault asked faculty respondents about their collaboration with industry, patent or intention to patent behavior, and spin-off company intention. In her survey, independent variables were captured through five-point Likert scale items asking how each individual would report his or her position on a scale with 1 being pure Mertonian ideals and 5 being pure academic capitalism. She also asked study subjects to rate their perceptions of their universities' entrepreneurial behavior. Renault used publication counts and total external funding received by the university on which the faculty member was named to measure the quality of the researcher. Institutional intellectual property policy and royalty, sharing policy was used to assess economic incentives for faculty. Other dummy variables were used to control for institution type. Renault's research hypothesized that, with respect to faculty involvement in technology transfer, a faculty member's place on the continuum was a predictor of technology transfer activity. She found that faculty members who fell on the academic capitalism side of the scale were significantly more likely to collaborate with industry and engage in patenting behavior as a means of getting the discovery to market (Renault, 2006). Other research suggests that faculty who patent do so because of the personal and professional protections it provides (Owen-Smith & Powell, 2001).

Of fame, freedom, and fortune, which one plays the greatest role in the researcher's decision to be involved with technology transfer? Some scholars have asked this question with regards to fortune with the purpose of finding a link between incentives/royalty-sharing policies and licensing income as well as faculty involvement in technology transfer. The findings have been mixed, but with a bulk of the literature pointing to a positive relationship between incentives and royalty sharing policies and faculty output related to technology transfer (DeVol et al., 2006; Powers, 2000; Renault, 2006). Typical royalty-sharing policies would divide the licensing income into three equal parts: one-third to the inventor, one-third to the university, and one-third to the academic department (Graff et al., 2002).

Renault (2006) found that royalty-sharing policy had a positive impact on faculty involvement but that the policy was overshadowed by tenure and promotion policy. Friedman and Silberman (2003) discovered that although higher royalty sharing to the inventor did not necessarily yield greater technology transfer outputs, it did result in higher university income. Their findings are supported in a different study by Lach and Schankerman (2004) which stated that university income is dramatically increased when there is an increase in royalty sharing. Considering the overall effectiveness of the technology transfer enterprise at a university, Link and Siegel (2005) performed a thorough econometric study and found that incentive policy has a positive relationship with the effectiveness of university technology transfer. With that said, another study showed that incentives to scientists and departments actually have a negative impact on entrepreneurial activity (Markman, Gianiodis, Phan, & Balkin, 2004). In Powers's (2000) study, it was also shown that royalty-sharing policy does not have a significant impact on university licensing income.

With respect to royalty-sharing policies as a motivating factor, the answer still seems to be undetermined. Powers (2000) performed a multivariate statistical regression model that validated his findings. With respect to the research that has shown a positive relationship between royalty-sharing policies and faculty involvement, it is also well performed. Link and Siegel (2005) is the prime example of a well-validated study that utilized credible econometric models. One possible explanation, in my opinion, could be a shift in attitudes from when Powers (2000) conducted his research and the present. It is possible that Mertonian norms of science are being vacated and more and more scientists are subscribing to the norm of academic capitalism.

A body of scholarship has grown around the role of the norms of science and faculty (Braxton, 1986, 1990, 1993, 1999; Braxton & Baird, 2001) as well as academic entrepreneurship and research commercialization (Anderson, 2000, 2006; Anderson et al., 2007, 2010; Macfarlane & Cheng, 2008). Recently Mertonian norms have also been investigated as they relate to academic administrators (Bray, 2010). The following paragraphs will outline the findings of this body of scholarship as they directly relate to developing a survey instrument to measure faculty adherence to the norms of science. All of the available survey items used in each study are presented in Appendix A.

Braxton (1990) tested social control theory using the norms of science as independent variables on a national sample of faculty in seven different academic disciplines. The data source was the 1977 survey of the American Professoriate, which was conducted by Ladd and Lipset (as cited in Braxton, 1990). Braxton used a subset of the survey that represented 795 survey respondents who held full-time faculty positions in the fields of biology, chemistry, economics, physics, political science, psychology, and sociology. Braxton utilized 14 survey items as variables in his study: four dependent variables, eight independent variables, and two control variables. Each dependent variable and each independent variable represented one of Merton's four norms of science. Two survey items mapped to the norm of universalism, three to communalism, one to disinterestedness, and five to organized skepticism. Braxton tested two hypotheses using multiple regression. His first hypothesis was to test if academics perceiving their colleagues as less adherent to the norms of science evidenced a greater likelihood of deviating from the norms of science. His second hypothesis was to test if a faculty member who had a weaker internalization of the norms of science corresponded to a greater likelihood of that faculty member deviating from the norms of science. Braxton found both hypotheses to be true with a strong significance across all four norms. It also held true that, even though internalization of the norms was of great importance, so too was the perceived adherence to the norms by academic colleagues. Braxton stated that a limitation of the study was the low coefficient alpha for items representing communalism, universalism, and organized skepticism. Disinterestedness was represented only by one item, which was another limitation of the study, especially as it would apply to a study requiring factor analysis and instrument development.

Braxton (1993) used data from the 1977 survey of the American Professoriate to test anomie theory on deviancy from the norms of science. Anomie theory explains that individuals within a socially-constructed environment with agreed-to goals, values, and norms, will deviate from the norms because the structure of the social environment makes it difficult to attain the prescribed goals while operating within the socially agreed-upon norms (Merton, 1968). Typically, according to Braxton (1993) and Merton (1968), some individuals are led to believe they should be able to achieve the group goals, and an inability to do so results in alienation, which leads to deviancy from the group norms. Braxton (1993) utilized survey responses from the Ladd and Lipset survey for his study on utilizing anomie theory, thus the dependent variables represented alienation from the reward system of the academic community. The independent variables were the same norm-related survey items used in Braxton (1990). Cronbach alpha limitations of the independent variables remained the same.

In a study pulling from two national surveys of 4,000 faculty and doctoral students in chemistry, civil engineering, microbiology and sociology, Anderson (2000) found that both faculty and students subscribed to the norms of science but were also prone to seeing deviant behaviors exhibited by their colleagues. The survey method utilized the four Mertonian norms of science and their respective Mitroff counter-norms of science. For each norm and counter-norm a survey item was developed. Survey respondents were asked to rate the level to which they subscribed to the item and to what extent they saw colleagues exhibiting subscription to the particular item. The items were to be scored as 2 if the respondent claimed "to a great extent," 1 if the respondent claimed "to some extent," and 0 if the respondent claimed "very little or not at all" (Anderson, 2000, p. 448). Scores on the Mertonian norm scale represented "subscription to the norms" (Anderson, 2000, p. 451) and scores on the Mitroff counter-norms represented "subscription to counter-norms" (Anderson, 2000, p. 451). The four item scores for subscription to norms and subscription to counter-norms were summed; each ranged from 0 to 8. Anderson (2000) utilized *t*-tests or *F*-tests for differences of means and hierarchical linear modeling in her analyses. While the survey design elicited responses that represented the norms and counter-norms of science, no psychometric analyses were reported for the survey instrument. The items used in the survey were like those used by Braxton (1990, 1993) and represent a good building point for developing an instrument that will be subjected to psychometric analyses.

Anderson et al. (2007, 2010) utilized survey items from the Acadia study, a national survey of 3,600 randomly sampled scientists supported by the NIH and a random sample of

4,160 postdoctoral trainees, to investigate normative dissonance in science and scientists subscriptions to the norms respectively. The survey instrument used included items representing the norms and counter-norms of science. The items included all four Mertonian norms and their respective Mitroff counter-norms. Based on outcomes of an extensive focus group phase of their study, Anderson et al. also included the norms of governance and quality along with their respective counter-norms of administration and quantity. In designing the survey Anderson et al. used one item for each of the norms and counter-norms and asked the respondent to rate it in three different ways. The three ratings were to assess subscription, enactment, and perceptions of the norms and counter-norms. Subscription corresponded to individual subscription to the norm while enactment corresponded to how the respondent rated his or her own behavior related to the norm. The perception rating corresponded to how the respondent saw the norm or counter-norm reflected by the greater scientific community. The scoring system was 2 for "to a great extent," 1 for "to some extent," and 0 for "very little or not at all" (Anderson et al., 2007, p. 6). In investigating normative dissonance (Anderson et al., 2007), it was found that for both early- and mid-career faculty there was a greater subscription to Mertonian normative behavior than to Mitroff counter-norm behavior. At the same time, respondents stated they perceived their academic counterparts as behaving in ways more consistent with Mitroff counter-norm behavior than Mertonian normative behavior.

Bray (2010) used a quantitative method in examining the proscriptive norms faculty held for the behavior of academic deans. A 123-item survey was developed based on American Association of University Administrators (AAUA) and AAUP guidelines and other articles and related to the role of the dean. Based on a stratified, random cluster sample, the survey was administered to a total of 800 faculty members at research and liberal arts institutions. For each institution type 100 faculty in the disciplines of biology, chemistry, history, and sociology received the survey. Bray utilized both exploratory and confirmatory factor analysis in investigating how items grouped on the four Mertonian norms of science. Exploratory factor analysis was used in allowing the norms to which faculty held their deans accountable to emerge. Confirmatory factor analysis was used to see if items indeed would group onto the four Mertonian norms of science. In performing his confirmatory factor analysis Bray produced 13 factors. Bray's scholarship is the strongest attempt to date at using psychometric analysis to test an instrument measuring the norms of science, but "the factors lacked the cognitive coherence to make good models for the norms of science approach" (p. 305).

Summary

The scholarship covered in this literature review provides a foundation for the development of an instrument tested for psychometric properties that will measure faculty adherence to the norms of science. Although scholarship has emerged that has investigated the role of the norms of science as it relates to faculty researchers and faculty involved in technology transfer, the gap in scholarship is the need for a *valid* and *reliable* instrument to test for faculty adherence to the norms of science. When developed the instrument can advantage further research related to numerous subjects such as ethical practice; faculty teaching, research, and service productivity; workplace satisfaction; and numerous other investigations with relevance to the higher education industry.

CHAPTER 3

Methodology

The purpose of this study was to develop a valid and reliable instrument to measure faculty adherence to the norms of science. Developing a valid and reliable instrument required two phases. Phase I comprised the development of the instrument and Phase II included the steps for testing the instrument's validity and reliability. The two phases involved a total of nine steps. These two phases provided a framework and comprehensive approach to developing the instrument and then testing the instrument's reliability and validity.

In discussing the methodology in this chapter, the participants in the study and the steps required for research involving human subjects are discussed first. From there, a formalized discussion of Phase I and its six steps is presented. Following the explanation of Phase I is a detailed explanation of Phase II and its three separate steps. Ending this chapter is a summary of the methodology used for this study.

Participants

There were two sets of participants for this study. For Phase I: Instrument Development, the participants were five expert faculty and researchers in scientific disciplines. One participant had patented an invention and one participant had produced scholarship pertaining to researcher subscription to the norms of science. These participants were asked to review the content validity of the instrument developed during Phase I of the study.

The participants for Phase II: Test Administration were a convenience sample of faculty in the disciplines of biology, chemistry, engineering, and medicine from Midwestern universities in the United States. These four disciplines were chosen based on the finding in Anderson et al. (2010) that faculty in these disciplines exhibited significant differences in subscription to the norms and counter-norms of science. Minimum eligibility for participants was to hold a tenure-track position within one of the above-mentioned scientific disciplines. Based on Costello and Osborne's (2005) article outlining best practices for factor analysis, a participant-to-instrument survey item ratio of 10:1 was used. Although Costello and Osborne (2005) found that a ratio of 20:1 yielded the highest possibility of correct solutions and reduced the number of misclassified factors, they also stated a *rule of thumb* ratio of 10:1 is adequate. A sample of 1,105 participants was used with an intended response rate of 30%. The selection of the participants entailed combing department web directories at Midwestern research universities and recording faculty names, affiliate department, and e-mail addresses for 1,200 faculty within the scientific disciplines of chemistry, biology, engineering, and medicine.

Procedures for the Review of Research Involving Human Subjects

Because this study included human participants it was necessary to comply with the human subjects requisites as stated by the College of Graduate and Professional Studies at Indiana State University (ISU). Per instructions of the ISU Institutional Review Board (IRB) forms were submitted for approval after the successful defense of this dissertation proposal. These forms included an Application for Review of Research Involving Human Subjects and the Expedited Review Research Categories Form C.

Instrument Design

Constructing a reliable and valid instrument required a prescribed guideline of activities. The method for instrument development chosen for this study was divided into two phases with Phase I having six separate steps and Phase II having three separate steps. The flowchart in

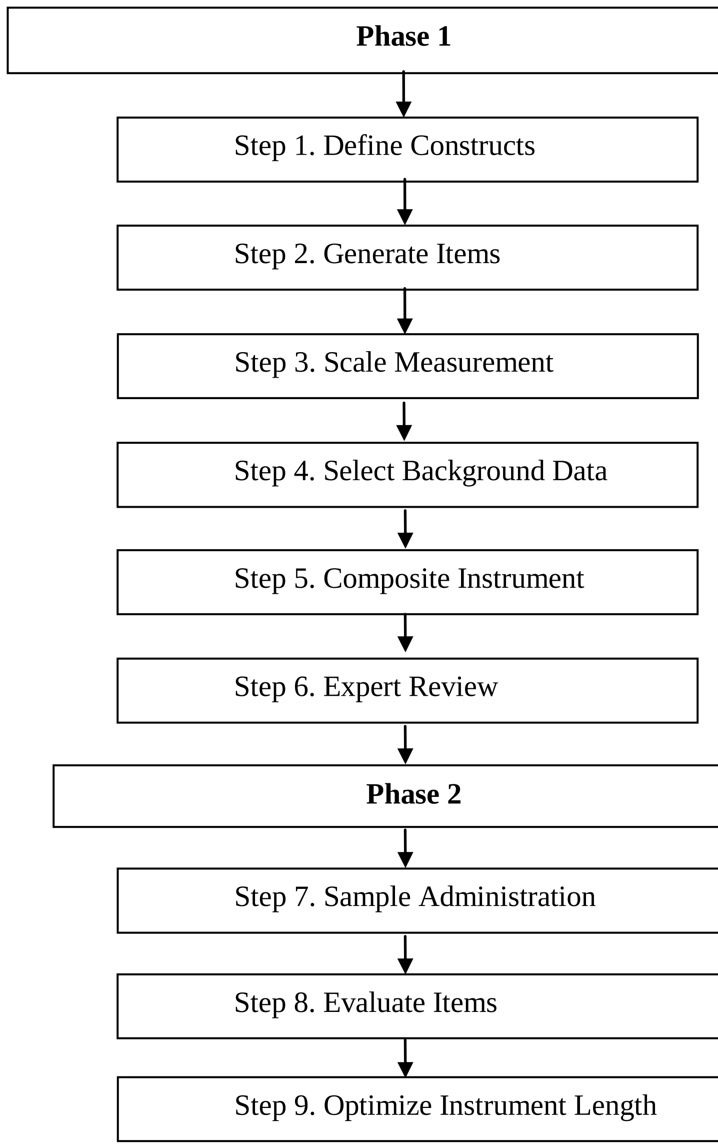

Figure 1. Devellis's (2003) phases of instrument development

Figure 1 provides a visual adaptation of Devellis's (2003) prescription. The core of this methodology required a review of construct validity and internal reliability that is discussed in the next section of this chapter.

Validity. Construct validity tests if the underlying norms are the causes for item covariation, or more simply, validity testing was used to determine how well the instrument actually measured what it intended to measure. Testing and showing an instrument is reliable is no guarantee that the underlying variable is the one in which the researcher should be interested (DeVellis, 2003).

Although there are many forms of validity testing, DeVellis (2003) discusses three types of validity: content validity, criterion-related validity, and construct validity. Content validity refers to the scale items' ability to accurately represent the content domain. In the case of this study the content domains are the norms of science. This type of validity is also referred to as face validity and was measured by soliciting input from a panel of experts in the content domain. The input given by the panel related to each item's ability to, on its face, reflect the content domain it intended to measure. Criterion-related validity can be explained as predictive validity, which is not something this study attempted to accomplish, although it represents an opportunity for future research to explore the degree to which the norm scales may be associated with related phenomena. Construct validity refers to the "extent to which a measure 'behaves' the way that the construct it purports to measure should behave with regard to established measures of other constructs" (DeVellis, 2003, p. 53). What this allows is for an amount of certainty in stating that the measure captures the individual variation in each norm as opposed to only one norm, or two, being the driving force behind item covariation. It could be possible that all four norms represent one domain or factor.

For this study verification of construct validity was accomplished through principal components analysis with varimax rotation (Tabachnick & Fidell, 2000). The first principal components analysis pass determined any latent variables, also referred to as factors, average communality of the scale items, and their eigenvalues. Considering the number of this study's initial scale items, 25 for initial testing, and with the number of participants being more than 250, the mean communality was required to be greater than .60 (Mertler & Vannatta, 2002; Tabachnick & Fidell, 2000). Based on Kaiser's rule, factors with eigenvalues ≥ 1.0 were extracted for factor analysis provided the average communality was greater than 0.6. Along with eigenvalues an inspection of the scree plot and the mean communality value was also taken into consideration. The scree plot inspection looked for a steep and straight line for the first few factors with eigenvalues above 1.0. Where the curve of eigenvalue points flattened out was the point of interest. The points above the flattening of the scree plot were considered for further analysis.

While the scree plot aided in determining results, performing the varimax rotation aided in result interpretation. Varimax rotation, an orthogonal rotation, increased the observable magnitude of item loading onto the extracted factors. The rotation did not change the underlying data but increased the visibility of the relationship of the item to the extracted factor which aids in researcher ability to interpret the results. A common rule for interpreting factor loadings draws a cutoff at a factor loading of .32, where items with a factor loading below .32 would not be included in interpreting the factor (Tabachnick & Fidell, 2000, p. 625). Although a factor loading of .71 is considered excellent and .32 is poor, the factor loadings used within that range are left up to the researcher's discretion. Ultimately the solution and model used was the one that had an optimal number of factors to explain at least 70% of the total variability or made the most interpretive sense. The Statistical Package for the Social Sciences (SPSS) was used to analyze the data after the final instrument was administered (Tabachnick & Fidell, 2000).

Reliability. The intent of the instrument was to measure a participant's adherence to the Mertonian norms of science or their Mitroff counterparts. By design the instrument was developed to capture the participant's adherence to a scientific norm or counter-norm. Reliability of the instrument and its subscales is defined as the "variance attributable to the true score of the latent variable" (DeVellis, 2003, p. 27). In the case of this instrument, the latent variables were the norms of science discussed in Chapter 2. If a psychometric instrument is reliable then variance in the responses to scale and subscale items would be caused by a participant's level of identification with the underlying construct. Testing for instrument reliability could have taken place in many forms. Following DeVellis's (2003) prescription a test for internal consistency was utilized.

Internal consistency refers to the agreement among participants taking the instrument and the instrument's consistency in measurement. In the case of this study internal consistency reliability refers to the agreement among participants on each of the four norms of science scales. In more general terms, the items in an instrument or scale designed to measure a specific phenomenon would be highly intercorrelated. Strong correlation among scale items implies a strong link between items and subsequently a strong link back to the latent variable (DeVellis, 2003, p. 28). More specifically for this study, the instrument's internal consistency refers to the intercorrelation among scale items developed to measure adherence to a specific scientific norm and the scale's ability to consistently measure each participant's adherence to the norms of science.

Cronbach's alpha is widely used to measure instrument reliability (Devellis, 2003). Devellis (2003) prescribed other methods for different types of scales but states Cronbach's alpha is the general test used for multiple response options. In short, Cronbach's alpha represents the actual variation across participants in the phenomenon being measured. Alpha represents the variation attributed to the change in the latent variable being measured. All other variation is due to error or what could be considered noise. A way to view this mathematically is "error variance = 1 – alpha" (DeVellis, 2003, p. 29). Alpha can equal 0 through 1. DeVellis explained that there is a debate about what level of alpha is acceptable, but he stipulates the following: unacceptable <.60; undesirable between .60 and .65; minimally acceptable between .65 and .70; respectable between .70 and .80; and very good between .80 and .90.

Instrument Development Phases and Steps

The following section describes the six steps in Phase I (steps 1-6) of the method chosen for development of the instrument as well as the three steps for Phase II (steps 7-9).

Step 1 - define constructs. Before endeavoring to develop any measurement instruments it is important to first have clearly defined and articulated what the instrument will measure (DeVellis, 2003). This scale was based on Merton's (1973) theoretical work related to the norms of science. The first step in clearly defining the norms pulled directly from Merton's definition of the norms as well as leveraging other explanations of the norms such as Mitroff's (1974) work on codifying counter-normative behavior of scientists. Having gone through this first step of clearly and specifically defining each norm to be measured was imperative to the success of the study.

Step 2 - generate items. After having clearly defined what it was the instrument was to measure, the next step was to generate a pool of items for the instrument. As Devellis (2003) stated, the item pool is a sample of the infinitely large population of possible items that could adequately represent the underlying norm. Since the goal of this study was to develop a 20-item instrument, a minimum item pool of 30 items was initially generated (DeVellis, 2003). Collecting and generating the items took place in three phases. The first phase consisted of reviewing studies that had built surveys based on Merton's norms or Mitroff's counter-norms of science. While adaptations of these items created a foundation more items were needed as per the guidelines in DeVellis. For the second step in the item generation phase, I generated a number of items. The third step of item generation was to modify items based on responses from the expert panel of reviewers whose input was requested during the content validity phase of this study.

Step 3 - scale measurement. The next step of the instrument development process was to select the scaling method. After reviewing DeVellis (2003) and observing the Likert scale format used in other faculty surveys (Macfarlane & Cheng, 2008), the Likert scale measurement system was chosen for this study. Likert scales are commonly found in instruments that measure opinion, beliefs, and attitudes. Likert scale items include a declarative statement followed by a range of responses, generally evidencing varying degrees of agreement with the statement. The measurement scale chosen for this study was a 1 to 6 forced-choice Likert scale, with 1 indicating strong agreement with the statement while the rest of the scale continues with *moderately agree, mildly agree, mildly disagree, moderately disagree,* and *strongly disagree.* While DeVellis explained that there is debate about whether or not an odd-numbered set of responses should be used to provide a neutral point, the six-point scale provides an adequate range for perception discrimination. In order to avoid capturing ambivalence or apathy toward scientific norms, the six-point Likert forced-choice scale was chosen.

Step 4 - select background data. Background data to be collected was designed based on a review of previous studies surveying faculty about their subscription to Mertonian scientific norms (Andersen, 2001; Anderson, 2000; Macfarlane & Cheng, 2008). Background data planned for collection included tenure status, academic discipline, gender, years in academia, and patent activity. If a participant indicated she or he was not minimally tenure-track, then the participant's results were excluded from the final analysis.

Step 5 - composite instrument. This step took the instrument from a concept and turned it into an electronic and paper document with instructions for completion, items, Likert scale responses for each item, and the background items at the end of the instrument. It was the step where the survey to be implemented was created. The composite instrument that was ultimately developed for electronic administration consisted of 25 survey items and a number of background questions. Step 5 did not put the instrument into its final form, however. It was only after the expert panel review that this was possible.

Step 6 - expert review. When the composite instrument was prepared, it was reviewed by the panel of six experts noted in the participants section of this chapter. The experts were contacted by e-mail to request their input and an electronic copy of the draft document was provided to them. The document began with a brief explanation of the study, its importance, and its approval by ISU's IRB and definitions of the norms of science being measured. The composite document included each Likert scale item along with an opportunity for the reviewer to comment on the instrument and to critique items where necessary and to offer suggestions. The reviewer had space to put comments if he or she chose. The final portion of the document solicited further input from the reviewer related to any potential items he or she thought should be considered. The level and quality of the feedback received led to the revision of the instrument to be revised a total of eight times.

Step 7 - sample administration. The 25-item instrument was tested in two phases. The first phase consisted of a very small administration to a convenience sample on campus to check for coding errors, to discover any difficulties in completing the survey, and to estimate the time needed to complete the survey. The second phase consisted of electronic administration of the instrument to the sample of 1,105 faculty members at Midwestern research universities. The names, e-mail addresses, and affiliated departments were added to a spreadsheet for merging into a Qualtrics panel for survey administration. Qualtrics is an electronic, web-based survey administration tool licensed by ISU for use by its faculty, staff, and approved students. After cleaning the data in the spreadsheet and spot-checking five random records for accuracy, the spreadsheet with names, e-mail addresses, and affiliated departments was uploaded to Qualtrics as a survey panel for electronics administration.

When the 1,105 faculty members and e-mails were selected the survey was administered through ISU's Center for Instruction, Research, and Technology. The software used to administer the instrument was Qualtrics. All data was stored securely on ISU's servers. The 1,105 participants were solicited through a Qualtrics administered e-mail with a brief e-mail alerting them of the confidential study's purpose. Three days later another personalized e-mail was sent and participants were presented with a link to the survey. Three response-facilitation techniques were used to aid in maximizing the response rate. The first technique used was message personalization where the e-mail solicitation for participation and follow-up e-mails were personalized and addressed to the individual faculty member (Dillman, 2007). The second response-facilitation technique was the pre-notification e-mail alerting the participant about the study, when he or she should expect to receive a link for the survey, and when follow-up e-mails would be sent (Dillman, 2007). In a meta-study investigating 308 survey administrations Van Horn, Green, and Martinussen (2009) found that surveys to fixed samples administered with one to three or more follow-ups showed increased weighted average response rates from 45% to 65%. Dillman (2007) explained that in designing follow-ups it is important to have each follow-up explain the purpose and importance of the study more deeply than the e-mail before it. Dillman likened the process to a sales pitch in which the salesperson does not go into the lengthy explanation of the product’s benefits if the prospect purchases (i.e., completes the survey) on the first ask. Not responding to the initial survey request is like an objection from a potential customer. A different approach in the follow-up e-mails is needed in overcoming the objection. Two follow-up e-mails were tailored in this study to very briefly further define the purpose and importance of the survey.

Confidential data collection in this study lasted for four weeks. The pre-notification e-mail was sent in April 2011. The e-mail containing the instrument was sent three days later. After the e-mail with the survey link was sent, a follow-up e-mail was sent after a one week period. The second follow-up e-mail was sent seven days after the first follow-up e-mail. The third and final follow-up e-mail was sent seven days after the second follow-up e-mail. Qaultrics’s confidentiality option was used in administering the e-mails to respondents. Qualtrics’s confidentiality option made it possible to monitor which respondents had or had not responded to the survey. When participants were flagged as having responded to the survey a personalized thank-you e-mail was sent and those participants were removed from follow-up e-mail reminders.

Step 8 - evaluate items. After data collection PASW was used to perform principal components analysis with a varimax rotation. Factor analysis is the statistical process by which items are discovered to group or load together, but not necessarily onto other factors. What follows is a description of the steps taken in PASW as outlined by Field (2005).

Setting up the factor analysis in PASW is straightforward but has many steps and options. The first step was to select the factor analysis option in PASW's data reduction tab. All variables, or instrument questions, were selected and moved into the variables box. Under the descriptive option in the factor analysis set-up area, all the options were selected: univariate, descriptive, initial solution, coefficients, significance levels, determinants, Kaiser-Myer-Olkin's measure of sampling adequacy, Bartlett's test of sphericity, inverse, reproduced, and anti-image. The correlation matrix was important for checking for multicollinearity. If strong multicollinearity is present, the collinear item(s) must be examined that correlate above $R > .8$, although the hope was to see groups of items correlate at the .4 level or higher.

After selecting the descriptive statistics to be included, it was then necessary to define the extraction method. For this study the principal components method was used. The analysis was set up to produce a correlation matrix, the unrotated factor solution, and the scree plot. Eigenvalues above 1 were extracted. The maximum number of iterations for convergence was set at 25.

After selecting the extraction method the rotation method was identified. As stated earlier, the rotation aided in the interpretation of the factor extraction results. Varimax rotation was used for this study and was set up to display the rotated solution and the loading plots. The loading plot aided in determining what scale items loaded onto which factors.

Before running the principal components extraction, SPSS was set up to save the factor scores as variables and some final options were selected. For this study the method of factor scoring to be saved was the Anderson-Rubin method. The factor scores are an estimation of what each participant might score on each factor if he or she were to be measured directly on the factor (Tabachnick & Fidell, 2000).

In the options of the factor analysis for SPSS utility, SPSS was programmed to exclude cases pairwise and to sort the coefficients by size. It is possible that a respondent will have elected not to answer a survey item. If there was a missing item SPSS excluded the case pairwise which means only that survey item was excluded, not the participant's entire survey. Listwise exclusion would have removed the entire survey for that participant. SPSS was also set up to suppress absolute values less than .32, which is the minimum factor loading score accepted during the first factor extraction (Field, 2005). After the options were selected the first extraction was run.

In analyzing the output the first analysis performed was the inspection of the abridged *R*-matrix. This matrix is used to test for high levels of multicollinearity, which could have been a problem if it was present. Significance values should be less than 0.05 and the correlation coefficients should be less than 0.9. The determinant should be greater than 0.00001. If the matrix falls within these numbers then multicollinearity is not considered a problem.

The second piece of analysis was an inspection of the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. The KMO measure of sampling adequacy determined if factor analysis was an appropriate statistical method for the data being analyzed. The KMO measure was displayed as a number between 0 and 1, with 0 indicating a diffused pattern of correlations and 1 indicating compact correlation patterns which would lead one to the conclusion that distinct and reliable factors should be present. A KMO of 0.5 to 0.7 is acceptable but mediocre, 0.7 to 0.8 is good, 0.8 to 0.9 is great, and above 0.9 is superb (Field, 2005). Bartlett's test of sphericity informed me that there are relationships between the variables, an assumption that necessarily must be met for factor analysis to be appropriate. For Bartlett's test, I looked for a significance level of 0.05 or lower.

The next step in the analysis was to investigate the factor extraction output which lists the eigenvalues of each factor before extraction, after extraction, and after the varimax rotation. The eigenvalues represented the percentage of variation explained by the factor, with the first factor listed explaining the greatest percentage of variation. SPSS then extracted all factors with eigenvalues greater than 1.0 and performed a varimax rotation. Varimax rotation equalized the percentage of variance explained by each extracted factor with an eigenvalue greater than 1.0.

After initial factor extraction and varimax rotation, PASW generated the communalities table and component matrix. The communalities for each survey item after extraction represented the percentage of variation of each item that is common or shared variance. As an example, if SPSS returned an item with an extraction communality score of .435 it could be said that 43.5% of the variance of that item is common, or shared variance. If the SPSS principal components analysis extracted four factors, then the component matrix would have consisted of four component columns and a number of rows equal to the number of items selected for analysis. The component matrix lists the factor loading of each item before rotation. This is a good beginning to understanding onto which factors the individual items load but not the matrix that will be used for interpretation. For further interpretation the rotated component matrix was examined.

The varimax rotation aided my interpretation of the factor loadings by increasing the magnitude of both high and low factor loadings. The matrix was sorted from highest to lowest loadings so as to further aid in understanding the output. Since the options section of the PASW factor analysis setup stipulated PASW drop any factor loading of .32 or below, there should have been blank factor loadings in the rotated component matrix. This was simply to aid in interpretation. The content of each item was investigated to see what the common thread was among items that loaded onto each factor. As an example for this study, if the rotated component matrix showed five survey items loading above the targeted .70 but not highly onto another factor, it suggests that those items made up a latent variable on some aspect of the norms of science.

After having extracted the factors it was then necessary to ensure each scale, or items loading onto a particular factor, were actually reliably measuring the same thing. Cronbach's alpha was generated through PASW for each factor scale to ensure each scale was reliably measuring the factor onto which it loaded. According to DeVellis (2003) an alpha score of 0.70 was desired.

Step 9 - optimize instrument length. The goal of this study was to develop an instrument to measure faculty adherence to the norms of science. Because shorter scales are seen to produce less burden on participants (DeVellis, 2003) an initial instrument was targeted to be 25 items in length. However, after any exploratory factor analysis, it could be concluded that one or many of the items do not load onto a factor or cross-load onto multiple factors. During internal reliability testing as well it was determined that certain scales did not pass the rigor of psychometric testing and needed to be discarded. Regardless, the goal of the optimization of instrument length is to either add or subtract items to produce the most valid and reliable instrument that does not unduly burden the participant. Based on the psychometric testing of the norms of science instrument, certain items were removed to increase the overall reliability of the instrument subscales.

Summary

Chapter 3 presented the methods used in developing and validating a reliable instrument to measure faculty adherence to the norms of science. A description of the selection process used to determined participants was presented along with the method employed for item generation. Data analysis and statistical methods used for the analysis were also introduced.

CHAPTER 4

Instrument Development and Data Collection

Chapter 4 presents the findings of this study. The instrument development process took two phases as discussed in Chapter 3. This chapter begins with Phase 1, the definition of the constructs and their subsequent item development and expert review for content validity. Following the discussion of Phase 1 is Phase 2, the electronic administration of the instrument and the results of the principal components extraction and varimax rotation to determine the instrument's construct validity. Cronbach's alpha analysis is also discussed as it relates to internal consistency of the different scales and instrument refinement.

The Development of the Norms of Science Instrument

Construct definitions. A review of the extant literature provided background for defining the initial constructs to be explored and utilized to develop question items. The constructs selected aligned with the four norms of science examined by Merton (1973) as described at length in Chapter 2. To summarize, these norms of science were communalism, universalism, disinterestedness, and organized skepticism (Merton, 1973). The counter-norms as defined by Mitroff (1974) were individualism, particularism, interestedness, and organized dogmatism. In defining the constructs for testing in the study, Merton's norms were the focal point while attitudinal disagreement with each definition would then capture the respective

Mitroff counter-norm. Table 1 shows the constructs, their definitions, and the corresponding references used in determining each construct's definition.

Table 1

Construct Definitions

Construct	Definition	References
Communalism	Communalism within the sciences is defined as the degree of openness regarding one's research and findings.	(Braxton, 1986; Merton, 1973; Mitroff, 1974)
Universalism	Universalism within the sciences is defined as the acceptance of research findings based solely on the merits of the scholarship and not the social background or status of the author.	(Braxton, 1986; Merton, 1973; Mitroff, 1974)
Disinterestedness	Disinterestedness within the sciences is defined as the degree to which a researcher pursues a research project or stream of research for purely altruistic reasons.	(Braxton, 1986; Merton, 1973; Mitroff, 1974)
Organized Skepticism	Organized Skepticism within the sciences is defined as only accepting knowledge or scientific findings, even one's own research findings, after it has been scrutinized through a logical and critical review.	(Braxton, 1986; Merton, 1973; Mitroff, 1974; Stehr, 1978)

Item Generation

After defining the constructs to be measured the items for the instrument were developed. The intent was to create enough items to have the opportunity of choosing the best items for the final instrument as would be revealed through psychometric testing. To accomplish this, a number of sources were referenced that had explored possible scale items, although not tested statistically. Table 2 lists the survey items found in the literature. They are also included in the appendix of this dissertation.

Table 2

Survey Items from Extant Literature

Source	Norm	Item
Ladd and Lipset (as cited in Braxton, 1990, 1993)	Communalism	In general, scientists and scholars are unjustified in keeping their research findings secret.
		Scientists and scholars have the obligation to acknowledge intellectual property by pertinent citations and references.
		Scientists and scholars should be willing to inform others investigating similar problems about their work in progress.
	Disinterestedness	Scientists and scholars should prefer critical evaluation by competent peers to public acclaim.
	Organized Skepticism	Scientists and scholars should critically examine others' contributions that they are using in their own work.
		Scientists and scholars should be skeptical even about their own research findings until competent peers have evaluated them.

Table 2 (continued)

Source	Norm	Item
		Scientists and scholars have an obligation to present available evidence that contradicts their hypotheses.
		No matter how deeply persuaded scientists and scholars may be that their ideas are sound, they must take account of critical appraisals of these ideas by competent peers.
		Scientists and scholars ought to question their findings if these cannot be independently reproduced by any others in the field.
	Universalism	The acceptance or nonacceptance of scientific and scholarly contributions should be judged on the evidence and not on the social characterstics [such as race or sex] of the authors.
		The standing accorded scientists and scholars in their fields should depend on the quality and extent of their contributions, not on their personal or social characteristics.
Anderson (2000, 2007, 2010)	Universalism	Scientists evaluate research only on its merit, i.e., according to accepted standards of the field.
	Communalism	Scientists openly share new findings with all colleagues.
	Disinterestedness	Scientists are motivated by the desire for knowledge and discovery, and not by the possibility of personal gain.
	Organized Skepticism	Scientists consider all new evidence, hypotheses, theories, and innovations, even those that challenge their own work.
	Particularism	Scientists assess new knowledge and its applications based on the reputation and past productivity of the individual or research group.

Table 2 (continued)

Source	Norm	Item
	Individualism/ Secrecy	Scientists protect their newest findings to ensure priority in publishing, patenting, or applications.
	Self-interestedness	Scientists compete with others in the same field for funding and recognition of their achievements.
	Organized Dogmatism	Scientists invest their careers in promoting their own most important findings, theories, or innovations.
Macfarlane and Chang (2008)	Communism	in favor of sharing teaching materials with peers and results of their research in progress.
	Secrecy/ Individualism	I tend to be secretive about my research in progress as I am concerned that someone else may beat me to publication.
	Communalism	As far as possible, I try to ensure that my intellectual work is not influenced by my personal beliefs and values.
	Universalism	I think the extent to which research may be generalisable or valid beyond its immediate context is important.
	Disinterestedness	I align my research interests with funding opportunities.
		I only pursue research that is of personal interest to me.

Content Validity

Before determining the content validity of the instrument, the items were generated. Item generation, for this study, involved a review of the survey items presented above from the literature as well as the definitions of the constructs found in Merton (1973), Mitroff (1974), and

Stehr (1978). In designing the items the goal was to capture the range of possible issues within a construct area and augmenting it with new items that my advisor and I felt reflected the current state of research science.

The instrument went through a set of initial drafts before being reviewed for content validity by an expert panel of reviewers. As discussed in Chapter 3, these five experts were asked to review the specific items, norm definitions, general format of the survey, and to assess it for content validity. Each participant was chosen based on his or her expertise with a number of important topics. These topics included expertise in statistical methods related to instrument development and factor analysis, quantitative methods, a deep understanding of technology transfer and researchers in the life sciences, expertise related to the norms of science and their measurement, and academic and research experience as a researcher in the life sciences discipline.

The instrument was developed through a number of iterations and an expert screening process. Survey items found in extant literature were used as models for initial item generation. Items were also generated based on the definitions of the norms found in Merton (1973), Mitroff (1974), and Stehr (1978). When initial items for the survey were written they were critiqued by the dissertation committee chair and a life science researcher at ISU. Refinement of the instrument took place after this consultation. After item refinement, the instrument was subjected to further internal review by an academic engineer and an academic statistician, both at ISU. Further item refinement was completed before the instrument was sent to the expert panel for their review. After the expert panel comments were received, the instrument was refined a final time in consultation with the dissertation chair. After the final approval by the chair, the instrument was put into electronic format for online administration and tested for coding and length of time to complete. The design of the instrument went through seven drafts under the supervision of the dissertation committee before being reviewed for content validity by an external panel of experts. The final instrument consisted of brief instructions for each section of the survey. While the earliest iterations of the survey also included definitions for each norm, these were removed in accordance with a suggestion made by a member of the expert review panel. The reviewer commented that definitions could skew the results by leading participants to answer relative to the definition provided. The instrument sent to the external panel of experts is presented in Table 3. The final version of the instrument, in its electronic format, can be referenced in Appendix B.

Table 3

Norms of Science Instruments Items Sent to Panel of Experts

Construct	Item
Communalism	Generally, faculty researchers are justified in keeping their research findings secret.*
	Generally, faculty researchers should openly share all their findings with colleagues.
	It is appropriate for a faculty member to require a colleague to sign a non-disclosure agreement before being granted access to research findings.*
	Faculty should expect to receive open access to a colleague's research findings without signing a non-disclosure agreement.
	Faculty should acknowledge intellectual property by citing pertinent references and scholarly works.
	In general, the only property rights faculty should have to their findings is recognition and esteem.
	It is appropriate to delay the publication of research findings in order to apply for patent protection.*

Table 3 (continued)

Construct	Item
Universalism	Research findings should be judged on the evidence and not on the characteristics (gender, race, and ethnicity) of the author.
	The esteem awarded the faculty member by her or his respective field depends on the quality of the faculty member's contributions to the field, not personal characteristics.
	According to accepted standards of the field, faculty members should only be evaluated on the merits of their scholarly contributions.
	Research findings, regardless of the faculty member's national origin, should be judged only after the merits of the research have been assessed.
	The institution from which a faculty member received her or his highest degree should be taken into consideration when evaluating the faculty member's scholarly contributions.*
	During the peer review process, the reviewer should be aware of the lead author's past publications.*
	Generally, a faculty member's gender should be a good indicator of the overall acceptance of the faculty member's research findings.*
	Generally, when peer reviewing for a publication within your field, it is important to understand the national origin of the lead author.*
Disinterestedness	Public and media acclaim for a faculty member compensates for a lack of recognition by her or his academic peers.*
	Faculty members are motivated by a passion for discovery and knowledge, not by the potential for personal gain.
	Opportunities for funding are the most important variable in determining a research agenda.*
	A research finding's potential to bring personal gain to a faculty member is generally more important than what the finding can add to the body of knowledge.*

Table 3 (continued)

Construct	Item
	Recognition by ones' academic peers is generally more important than personal gain through national media attention.
Organized Skepticism	Scholars should critically evaluate the findings of other scholars.
	A scholar should be skeptical of her or his own findings until they are evaluated by colleagues.
	Faculty members should present evidence that contradicts their own hypotheses.
	Generally faculty members should not question their findings if they cannot be independently reproduced by colleagues in their academic field.*
	Regardless of how firmly a faculty member is convinced of her or his ideas, they should take into account criticisms of those ideas by competent peers.
	It is important for a faculty member to be able to highlight shortcomings in findings he or she has cited while justifying why his or her own hypotheses were not validated.*

Note. Items marked with * are negatively worded and intended for reverse coding.

As seen in Table 3, many of the items were worded to capture the opposite of the respective norm's definition. This negative wording was chosen to provide variability in the responses, especially if an individual strongly adhered to the particular norm. These negatively worded items were reverse coded for the initial statistical analysis and factor analysis portions of the study.

Data Collection

The survey instrument was administered electronically through Qualtrics. The survey was electronically administered during the month of April, 2010. A brief introductory e-mail was sent via the Qualtrics tool to the sample of 1,105 faculty researchers three days before the survey link was sent. While a number of participants responded via e-mail to the original e-mail blast, some also responded with regrets. If a participant responded asking to be removed from further e-mails, he or she was removed from the Qualtrics panel. As an incentive, both introductory e-mail, survey e-mail, and two follow-up e-mails included information about the chance to be entered into a drawing for a 16GB WiFi enabled iPad 2. Communication pieces are contained in Appendix C.

CHAPTER 5

Psychometric Analysis

Chapter 4 described the instrument development and in-field data collection phases of the study. This chapter begins with an explanation of the sample participants and descriptive statistics associated with the data collected. The section is followed by the statistics deployed to ensure the appropriateness of the data for factor analysis. After the assumptions, the factor analysis results are described and discussed. The chapter concludes with an explanation of the four-factor model that best fit the data.

Descriptive Statistics

Participants. A total of 290 participants completed or started the survey for a response rate of 26%. Data collection took place from April 11, 2011, to May 1, 2011. Two reminder e-mails were sent. One reminder e-mail was sent on April 18, 2011, and a final reminder was sent on April 25, 2011. Two-hundred eighty participants completed the entire survey for an effective response rate of 25%. This response rate resulted in a ratio of subjects to items of 11:1. A ratio of 10:1 or higher is considered appropriate for the conduct of factor analysis (Costello & Osborne, 2005); therefore a ratio of 11:1 met this criterion. Of the respondents, 202 (72%) were male and 78 (28%) were female. Eighty-four (30%) of the respondents reported being an inventor on at least one patent application and 118 (approximately 42%) reported being the primary investigator on one or more industry-sponsored projects. The academic disciplines were represented as follows: engineering 51 (18%); physics 2 (1%); chemistry 66 (23%); medicine, 74 (26%); other, 88 (31%). Of those who reported other, only one reported being in a field other than one that could be included in the life sciences. Academic ranks were represented as follows: assistant professor, 85 (30%); associate professor, 82 (29%); professor, 105 (37%); instructor or lecturer 6, (2%); adjunct faculty 1, (0.4%); and other 2, (1%). The two respondents in the *other* category for academic rank designated assistant research professor and named professor. One-hundred ninety-seven (70%) of the respondents reported the United States as their country of origin while 16 (5.6%) did not report a country and 73 (24%) reported a country other than the United States as their countries of origin.

Assumptions for Statistical Analysis

Before conducting the factor analysis, it was first necessary to establish that the data conformed to the necessary assumptions for this statistical procedure. SPSS statistics version 18.0 for Windows was used to run two screening tests on the data. The two tests were Bartlett's test of sphericity and the Kaiser-Myer-Olkin measure of sampling adequacy.

As mentioned in Chapter 3, Bartlett's test of sphericity is used to determine multivariate normality and accepts or rejects the null hypothesis that the data represent an identity matrix (Tabachnick & Fidell, 2000). For factor analysis and principal components extraction to return statistically significant results, it is imperative that there be a certain degree of correlation between item scores. An identity matrix, by definition, is a matrix where the diagonal scores are equal to 1 and all off-diagonal scores are equal to 0. An identity correlation matrix would represent perfect correlations between an item and itself and no correlations with any other item in the matrix. To verify the data collected for this study did not represent an identity matrix, Bartlett's test of sphericity was performed. To move forward with factor analysis, the Bartlett's test must be significant to allow rejection of the null hypothesis. Bartlett's test of sphericity returned a chi-square score of 1578.3 ($p < .001$). The null hypothesis was rejected and thus the data met this criterion for factor analysis.

The Kaiser-Meyer-Olkin measure of sampling adequacy was the next statistic performed. The KMO statistic is an index of the proportion of variance among the variables that is common (Tabachnick & Fidell, 2000). The index relates what proportion of variance might be common and therefore attributable to underlying latent variables. This test returns a score of 0 to 1, with a score above .60 indicating the data to be analyzed are appropriate for factor analysis. The KMO statistic for this study was .71 and hence the data met the expectations for factor analysis.

Because the data met the criteria for both Bartlett's test of sphericity and the Kaiser-Meyer-Olkin measure of sampling adequacy, the analysis continued to the principal components extraction. To aid in the analysis of subsequent sub-scales identified after the Varimax rotation, a factor loading score of .50 or greater was necessary for inclusion in the model. Although literature stated items loading at .33 or above could be included (Tabachnick & Fidell, 2000), for the purposes of this exploratory study, a higher threshold of .50 aided in identifying those items that most strongly load onto the underlying factor. As an aid to the analysis, the survey items are reproduced in Table 4 and as drawn from the final survey shown in Appendix B.

As a first step to the analysis, a correlation matrix was produced and is presented in Table 5. The numbers in the correlation matrix correspond to the numbered item in Table 4.

Table 4

Survey Items in the PASW Dataset

Item #	Item Text
1	Researchers should openly share findings with colleagues.
2	(R) The integration of confidentiality/non-disclosure language in contractual agreements between academic researchers for the sharing of research material, data, or findings is appropriate.
3	(R) It is appropriate to delay the submission of a piece of industry sponsored research for publication consideration so the firm can assess business implications.
4	(R) It is appropriate to delay the publication of findings for 60 days while the findings are evaluated for possible patent protections.
5	Research outcomes are not something that anyone "owns" but rather should be made freely available upon request.
6	(R) Non-disclosure agreements are a reasonable tool for protecting research findings from being used by others for potential financial gain.
7	The evaluation of a piece of research should be based upon the quality of the work and not the track record of the researcher.
8	Blind review is the only appropriate way to ensure that the best research is published.
9	(R) A researcher's grants and scholarship record is as important a consideration when evaluating a grant proposal as the merit of the research proposed.
10	(R) The institution that conferred a researcher's highest degree should be taken into consideration when evaluating scholarly contributions submitted to a peer-reviewed journal.
11	(R) During the peer review process, a reviewer should be aware of the lead author's past publications.
12	(R) The evaluation of a piece of research should consider the gender of the researcher.

Table 4 (continued)

Item #	Item Text
13	(R) Generally, when peer reviewing for a publication within your field, it is important to know the lead author’s country of origin.
14	(R) When reviewing a conference paper or journal article manuscript it would be helpful if the reviewers knew something about the author(s).
15	(R) The possibility of public and media acclaim for one’s research is an important consideration when starting a research project or direction of inquiry.
16	(R) The likelihood of achieving tenure is enhanced when a researcher pursues a scholarly stream that has consulting or revenue potential from the outcomes of that research.
17	Passion for discovery and not personal gain ought to be the driving force behind scientific endeavor.
18	In general, the only rewards researchers should expect to receive as a result of their findings are recognition and esteem.
19	(R) Opportunities for funding ought to drive choices for a research project or stream.
20	Science would benefit if more researchers chose to pursue projects based solely on the discovery of new knowledge free from considerations of personal benefit.
21	Researchers ought to be skeptical of the findings of other researchers.
22	A researcher should be as skeptical of one’s own findings as he/she is of others.
23	A researcher should seek evidence that contradicts his/her hypotheses.
24	Regardless of how firmly a researcher is convinced of one’s own ideas, he/she should take into account criticisms of those ideas by competent peers.
25	It is important for a faculty member to highlight study limitations in any research he/she seeks to present or publish.

Note. Items with an R in parenthesis are reverse coded.

Table 5

Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	1.000	.135	.096	.118	.434	.215	.104	.005	-.072	.030	-.102	.002	.119	-.025	.053	.104	.226	.128	.091	.108	.105	.098	.071	.122	.079
2		1.000	.242	.202	.100	.470	-.126	-.087	.050	.037	.004	.063	-.004	-.024	.109	.098	-.008	.004	.149	-.026	.058	.128	.026	.021	.046
3			1.000	.541	.297	.401	.006	.064	.109	-.044	.155	.104	.084	.222	.134	.150	.172	.054	.148	.212	-.021	.021	-.034	.069	.174
4				1.000	.189	.387	.018	.008	.095	-.028	-.002	.025	.115	.156	.171	.114	.034	.073	.101	.033	-.057	-.139	-.146	-.053	-.040
5					1.000	.215	.210	.124	-.003	-.031	.041	.036	.057	.101	.130	.154	.232	.287	.161	.260	.076	.074	.048	.124	.136
6						1.000	-.113	.006	.078	.080	.079	.061	.071	.049	.136	.094	.019	.092	.191	.044	.099	.190	-.022	.115	.165
7							1.000	.218	.086	.233	.104	.238	.183	.267	.096	.081	.110	.055	.048	.100	.031	.072	.056	.110	.073
8								1.000	.135	-.038	.068	.037	.017	.214	.083	-.071	.093	.188	.001	.200	.061	-.007	.036	.017	.082
9									1.000	.230	.157	.081	.036	.223	.160	-.063	.077	-.078	.108	.109	-.056	-.057	-.045	-.055	-.025
10										1.000	.251	.318	.286	.275	.240	.222	.027	-.082	.087	.034	.115	.230	.106	.223	.111
11											1.000	.141	.160	.325	.175	.013	.044	.004	.163	.149	-.114	-.023	-.124	-.015	.058
12												1.000	.380	.246	.246	.172	.052	-.079	.067	.092	.087	.151	.036	.091	.117
13													1.000	.388	.233	.192	.139	.073	.071	.075	.106	.112	.031	.129	.094
14														1.000	.241	.128	.132	.103	.072	.114	.016	.015	-.114	.009	.065
15															1.000	.300	.220	.050	.216	.177	-.041	.140	.015	.134	.110
16																1.000	.056	-.023	.061	-.021	.071	.102	.021	.119	.146
17																	1.000	.493	.161	.443	.134	.059	.215	.247	.278
18																		1.000	.156	.365	.100	.098	.095	.127	.176
19																			1.000	.307	.028	.065	-.004	.111	.209
20																				1.000	.081	.117	.098	.116	.202
21																					1.000	.583	.472	.272	.294
22																						1.000	.492	.391	.317
23																							1.000	.427	.380
24																								1.000	.452
25																									1.000

The matrix shows a range of correlations, a number of which are above .30. According to Tabachnick and Fidell (2000), some correlations above the .30 value need to be present before considering moving on to the factor analysis portion of a study. The correlation matrix also doubles as a tabular representation of what Bartlett's test of sphericity already had shown.

Factor Extraction

For the factor extraction procedure, the method chosen for this study was principal components analysis with a varimax rotation. The goal of principal components analysis is to identify patterns of correlations among observed item scores. Table 6 presents the results.

Table 6

Eigenvalue Scores Above 1.0 For Principal Components Extraction of the Norms of Science Instrument

	Initial Eigenvalues		
Component	Total	% of Variance	Cumulative %
1	3.88	15.5	15.5
2	2.56	10.2	25.7
3	2.18	8.7	34.5
4	1.92	7.7	42.1
5	1.36	5.4	47.6
6	1.19	4.8	53.4
7	1.05	4.2	56.6

The rubric used for initially considering the number of factors to be considered is eigenvalues greater than 1.0 and an inspection of the cumulative percent of variance attributed to the model (Tabachnick & Fidell, 2000). Ideally, a cumulative variance of 70% is desirable for the model. As it regards the findings from Table 4, all of the factors had eigenvalues above 1.0 and although the 70% threshold was not reached, that standard is a general rule of thumb and lower cumulative variance can be considered acceptable.

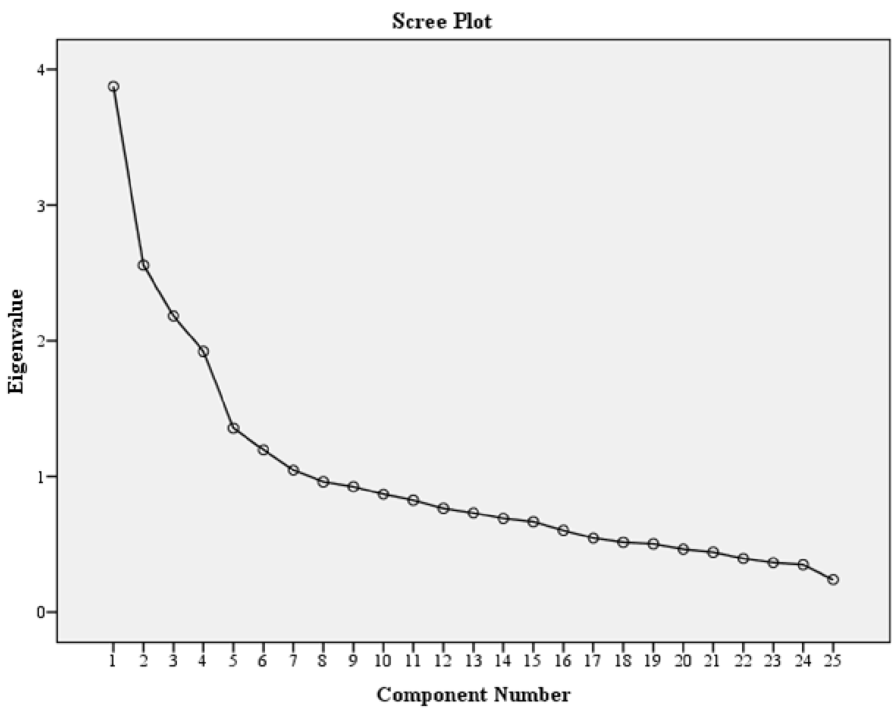

Figure 2. Scree plot

Table 7

Five Factor Solution to Principal Components Extraction with Varimax Rotation

	Component				
Items	1	2	3	4	5
1. A researcher should be as skeptical of one's own findings as he/she is of others. (Organized Skepticism)	**.783**	.130	.067	.000	-.019
2. A researcher should seek evidence that contradicts his/her hypothesis. (Organized Skepticism)	**.762**	-.047	-.110	.084	-.069
3. Researchers ought to be skeptical of the findings of other researchers. (Organized Skepticism)	**.706**	.037	-.005	.013	-.113
4. Regardless of how firmly a researcher is convinced of one's own ideas, he/she should take into account criticisms of those ideas by competent peers. (Organized Skepticism)	**.646**	.146	.035	.145	-.071
5. It is important for a faculty member to highlight study limitations in any research he/she seeks to present or publish. (Organized Skepticism)	**.597**	.078	.134	.273	.051
6. Generally, when peer reviewing for a publication within your field, it is important to know the lead author's country of origin. (Organized Skepticism)	.067	**.663**	.026	.044	-.073
7. The evaluation of a piece of research should consider the gender of the researcher. (Universalism)	.122	**.631**	.031	-.068	.074

Table 7 (continued)

Items	Component 1	2	3	4	5
8. The institution that conferred a researcher's highest degree should be taken into consideration when evaluation scholarly contributions submitted to a peer reviewed journal. (Universalism)	.258	**.618**	-.005	-.132	.245
9. When reviewing a conference paper or journal manuscript it would be helpful if the reviewers knew something about the author. (Universalism)	-.137	**.616**	.064	.237	.224
10. The evaluation of a piece of research should be based upon the quality of the work and not the track record of the researcher. (Universalism)	-.020	**.529**	-.236	.250	-.146
11. The possibility of public and media acclaim for one's research is an important consideration when starting a research project or direction of inquiry. (Disinterestedness)	.064	**.473**	.248	.156	.131
12. The likelihood of achieving tenure is enhanced when a researcher pursues a scholarly stream that has consulting or revenue potential from the outcomes of that research. (Disinterestedness)	.100	**.463**	.201	-.133	-.287
13. Non-disclosure agreements are a reasonable tool for protecting research findings from being used by others for potential financial gain. (Communalism)	.152	.017	**.785**	-.026	-.007

Table 7 (continued)

Items	Component 1	2	3	4	5
14. It is appropriate to delay the submission of a piece of industry sponsored research for publication consideration so the firm can assess business implications. (Communalism)	-.069	.121	**.687**	.224	.004
15. The integration of confidentiality/non-disclosure language in contractual agreements between academic researchers for the sharing of research material, data, or findings is appropriate. (Communalism)	.145	-.054	**.661**	-.172	.016
16. It is appropriate to delay the publication of findings for 60 days while the findings are evaluated for possible patent protections. (Communalism)	-.254	.127	**.653**	.070	-.129
17. Opportunities for funding ought to drive choices for a research project or stream. (Disinterestedness)	.121	.051	**.330**	**.330**	.244
18. Science would benefit if more researchers chose to pursue projects based solely on the discovery of new knowledge free from considerations of personal benefit. (Disinterestedness)	.128	.033	.093	**.711**	.148
19. Passion for discovery and not personal gain ought to be the driving force behind scientific endeavor. (Disinterestedness)	.207	.079	.040	**.695**	-.092
20. In general, the only rewards researchers should expect to receive as a result of their findings are recognition and esteem. (Disinterestedness)	.112	-.093	.039	**.690**	-.160

Table 7 (continued)

Items	Component 1	2	3	4	5
21. Blind review is the only appropriate way to ensure that the best research is published. (Universalism)	-.049	.098	-.113	**.448**	.114
22. Researchers should openly share findings with colleagues. (Communalism)	.073	.132	.229	.211	**-.621**
23. A researcher's grants and scholarship record is as important a consideration when evaluating a grant proposal as the merit of the research proposed. (Universalism)	-.091	.183	.145	.134	**.525**
24. During the peer review process, a reviewer should be aware of the lead author's past publications. (Universalism)	-.108	**.330**	.106	.171	**.500**
25. Research outcomes are not something that anyone "owns" but rather should be made freely available upon request. (Communalism)	-.003	.165	.301	**.460**	**-.480**

All five items tested for manifesting aspects of *Organized Skepticism* (Items 1 - 5 in Table 5 as shown in the first component column) loaded where expected (component scores ranging from .597 to .783) with little evidence of cross-loading. The other items in the survey had first component factor scores that were much smaller and hence exhibited little or no evidence for inclusion with this factor. Hence, it appeared *Organized Skepticism* is clear and distinct as a normative domain associated with the conduct of academic science.

Of the eight items tested under the domain of *Universalism* (Items 6 – 10, 23, and 24), five loaded highly (Items 6 - 10) with component scores ranging from .529 to .663. One of the three other items (Item 24) had suggestive evidence for being included in that factor, although with a factor loading of .33, it was well below the .50 threshold and clearly cross-loaded with the fifth component. Hence, it was dropped from consideration for any factor. The other two *Universalism* related items (Item 21 and 23) had very low loadings on the first factor component but did load highly on other factors. Hence, these were also dropped from inclusion in a *Universalism* factor. What also loaded moderately high on this factor, however, were two items from the original *Distinterestedness* domain (Items 11 and 12). However, because they fell below the .50 threshold as strong suggestive evidence of factor association while also showing at moderate evidence of cross-loading, they were dropped from consideration for this factor or any other factor. In summary, then, the data revealed that five items appear to clearly capture the normative academic science domain of *Universalism*.

Four of the six items crafted to capture aspects of *Communalism* (Items 13 - 16) loaded highly on that factor (factor scores ranged from .653 to .785) while the other two loaded highly on the fifth factor. One item from the *Disinterestedness* domain (Item 17) had suggestive evidence of loading with this factor (.33) but it also loaded highly on the fourth factor and hence was dropped from consideration for any factor domain. The other two *Communalism*-related items (Items 22 and 25) loaded highly and moderately highly on the fifth factor so were dropped as reflective of *Communalism*. No other items from the survey came close to loading on the *Communalism* factor. Hence, four items appear to be clearly reflective of the *Communalism* normative domain, but given their business and financial implications focus, the domain has been renamed *Commercialism*.

Three of the six items crafted to capture *Disinterestedness* loaded highly onto a fourth factor while the other three (Items 11, 12, and 17), as mentioned earlier either cross-loaded or had suggestive but not adequate evidence to be associated with another factor. Hence, all were dropped from further consideration as being clearly linked to one of the normative domains. One of the original *Universalism* items (Item 21) did show some evidence of being associated with a *Distinterestedness* factor, although just below the .50 threshold cutoff (loading of .448). However, because it showed very little evidence of cross-loading, it was retained with this factor. No other items in the survey came close to loading on this factor. Hence, four items appear to be reflective of the *Disinterestednes*s normative domain, but given their particular focus on traditional virtues of academic science, the domain has been renamed *Scientific Puritanism*.

A fifth factor had four items that loaded highly on it (component scores ranging from .480 to .621), two from the original *Communalism* domain (Items 22 and 25) and the other two from the *Universalism* domain (Items 23 and 24). Although Item 25 did load nearly at the .5 cutoff, it clearly cross-loaded and hence was dropped from any further consideration. No other survey items came close to loading on this factor. Based on the nature of the three items that were retained, this factor was labeled *Communal Meritocracy*. By *Communal Meritocracy* is meant the idea that scientific findings belong to the community but the researchers are rewarded based on the merits of the research and their track record as scholars.

Reliability Analysis

As presented and discussed above, factor analysis suggested a five factor solution was optimal with factors that evidenced solid construct validity. However, internal reliability is also important to instrument development. The next step in the research, then, was to test for internal reliability, a procedure that utilized the Cronbach's alpha statistic. Each scale identified by the analysis and named above was analyzed by using the alpha statistic. Table 8 summarizes the reliability analyses for the five-component model and using the final factor items indicated in the previous section.

Table 8

Reliability Analyses of Component Scales

Factor	*N*	Number of Items	Mean	*SD*	Variance	Scale Alpha
Organized Skepticism	282	5	9.46	3.058	9.353	.781
Universalism	283	5	9.41	3.179	10.109	.652
Commercialism	276	4	16.95	3.495	12.216	.703
Scientific Puritanism	282	4	10.39	3.316	10.992	.644
Communal Meritocracy	282	3	9.37	2.014	4.056	-.030

As the results show, all but one of the item sets falls within or near acceptable alpha ranges given that .7 is the ideal according to Devellis (2003) with others suggesting figures just below this being reasonable as well. The one that did not reach this threshold was *Communal Meritocracy*. In an effort to explore whether a smaller set of items within each of the five factors improved that factor's alpha score, different combinations of items were removed to see if the alpha score increased. Tables 7 - 10 present this analysis.

Organized skepticism. The five-item *Organized Skepticism* scale, with an alpha of .781, was the strongest scale. The alpha score is above the normally accepted alpha of .70 (DeVellis, 2003). As per Merton's (1973) theory in this arena, the degree to which one agrees to the norm of holding findings, even one's own findings, with a view of skepticism appears to be legitimately captured by these five items, suggesting that the scale is both valid and internally reliable. As shown in Table 9, removing different items only reduced the alpha, additional evidence that the five-item scale is strong and appropriate.

Table 9

Organized Skepticism (original alpha .781) Scale and Score If Item Removed

Item	Alpha if item deleted
A researcher should be as skeptical of one's own findings as he/she is of others.	.690
A researcher should seek evidence that contradicts his/her hypotheses.	.700
Researchers ought to be skeptical of the findings of other researchers.	.736
Regardless of how firmly a researcher is convinced of one's own ideas, he/she should take into account criticisms of those ideas by competent peers.	.745
It is important for a faculty member to highlight study limitations in any research he/she seeks to present or publish.	.752

Universalism. The *Universalism* scale of five items had a Cronbach's alpha score of .652, below the preferred .70 level, but although .70 is preferred, some studies do report alphas under .70 as legitimate (Tabachnick & Fidell, 2000). Hence, it appeared that this scale was also valid and reliable and that the items appropriately captured aspects of a common norm of science, namely the lens by which scholarship is judged and the degree to which aspects associated with the researcher are considered when evaluating scholarship. As shown in Table 10, removing different items only reduced the alpha, additional evidence that the five-item scale is strong and appropriate.

Table 10

Universalism (original alpha .652) Scale and Alpha If Removed

Item	Alpha if item deleted
(R) Generally, when peer reviewing for a publication within your field, it is important to know the lead author's country of origin.	.535
(R) The evaluation of a piece of research should consider the gender of the researcher.	.584
(R) The institution that conferred a researcher's highest degree should be taken into consideration when evaluating scholarly contributions submitted to a peer-reviewed journal.	.574
(R) When reviewing a conference paper or journal article manuscript it would be helpful if the reviewers knew something about the author(s).	.568
The evaluation of a piece of research should be based upon the quality of the work and not the track record of the researcher.	.613

Commercialism. The *Commercialism* scale of four items resulted in a Cronbach's alpha of .703, still within an acceptable range. Thus, it appeared that this scale was both valid and reliable and captured aspects of practice associated with commercialization. These norm elements included issues of non-disclosure and confidentiality agreements on research findings as well as publication delays in order to explore potential for patenting. Table 11 shows the items in the *Commercialism* scale along with the alpha if an item was removed. The analysis indicates the four-item factor as optimal, additional evidence that the scale identified through factor analysis is strong and appropriate.

Table 11

Commercialism (original alpha .703) Scale and Alpha If Item Removed

Item	Alpha if item deleted
(R) Non-disclosure agreements are a reasonable tool for protecting research findings from being used by others for potential financial gain.	.583
(R) It is appropriate to delay the submission of a piece of industry sponsored research for publication consideration so the firm can assess business implications.	.619
(R) The integration of confidentiality/non-disclosure language in contractual agreements between academic researchers for the sharing of research material, data, or findings is appropriate.	.697
(R) It is appropriate to delay the publication of findings for 60 days while the findings are evaluated for possible patent protections.	.622

Scientific Puritanism. The *Scientific Puritanism* scale of four items had an alpha of .644, once more an acceptable internal reliability score. This finding suggests that the scale is internally reliable and, as noted before, is also valid. Internal reliability tests with combinations of fewer factors as shown in Table 12 revealed that removal of Item 21 related to blind review in research improved the alpha slightly to .691. However, because it was not substantially different, the original four-item factor was retained.

Table 12

Scientific Puritanism (original alpha .644) Scale and Alpha Score If Item Removed

Item	Alpha if item deleted
Science would benefit if more researchers chose to pursue projects based solely on the discovery of new knowledge free from considerations of personal benefit.	.535
Passion for discovery and not personal gain ought to be the driving force behind scientific endeavor.	.517
In general, the only rewards researchers should expect to receive as a result of their findings are recognition and esteem.	.504
Blind review is the only appropriate way to ensure that the best research is published.	.691

Communal Meritocracy. The three items that loaded highly on a fifth factor and labeled *Communal Meritocracy* had a Cronbach's alpha of -.030, a reliability statistic that was below an acceptable value. To explore whether the alpha could be improved, different pair combinations were explored with the results shown in Table 13. The results were only marginal improvement and nowhere near the desired .70 alpha. Thus, it was clear that while this scale showed evidence of capturing a unique domain within the norms of academic science, it was not reliable. Hence, the *Communal Meritocracy* scale was removed from further consideration in the study.

Table 13

Communal Meritocracy (original alpha -.030) Scale with Alpha Score If Item Removed

Item	Alpha if item deleted
Researchers should openly share findings with colleagues.	.268
(R) A researcher's grants and scholarship record is as important a consideration when evaluating a grant proposal as the merit of the research proposed.	-.216
(R) During the peer review process, a reviewer should be aware of the lead author's past publications.	-.155

Instrument Optimization

The final step in DeVellis' (2003) scale development methodology is instrument optimization or affirmation of the process and result. To this end, the Norms of Science instrument began with 25 items and through factor and reliability analyses, 18 were found to be legitimate measures of aspects of four normative domains of academic science. These domain scales were labeled *Organized Skepticism*, *Universalism*, *Commercialism*, and *Disinterestedness*. The following summarizes the process by which the instrument was optimized and arrived at this outcome.

The initial principal components extraction produced a total of seven components with an eigenvalue greater than 1. Eigenvalue and scree plot analysis illustrated the viability of a four-, five-, or six-component model. After running the principal components extraction and performing the varimax rotation on the 25 items to maximize differences in factor loadings, it was found that some cross-loaded and had to be dropped and one (Item 21) loaded in a place not expected, making it necessary to explore even more deeply the nature of the domain phenomenon. The specifics on each of the scales are described next.

Organized Skepticism had the strongest alpha score and, based on the second alpha analysis, removing any items would weaken the strength of the alpha score from .781. Because the scale returned an alpha above .70 and subsequent analysis did not imply an improvement in the scale, none of the five items were removed from the *organized skepticism* scale.

Universalism returned an alpha score of .670 and subsequent analysis showed that removing any items would not improve the alpha score of this scale. As noted earlier, however, two items that marginally loaded onto *Universalism* were developed to capture dimensions of the normative concept of *disinterestedness* as described by Merton (1973). The items were "The possibility of public and media acclaim for one's research is an important consideration when starting a research project or direction of inquiry," and "The likelihood of achieving tenure is enhanced when a researcher pursues a scholarly stream that has consulting or revenue potential from the outcomes of that research." Both of these items refer to concepts of personal reward based on one's research. The first item posits the possibility of public acclaim—recognition outside the scientific community—as an incentive for choosing a research stream. The second item posits an enhanced opportunity for tenure if one chooses a stream of research that provides a source of revenue from the research outcomes. Based on their marginal loading and their suggestive evidence of cross-loading, as well as the conceptual differences observed between these two items and the norms of *Universalism*, they were removed from the final, optimized instrument.

Commercialism returned an alpha score of .703. Further analysis removing particular items did not improve the alpha score. As previously mentioned, however, a fifth item from the original disinterestedness scale, "Opportunities for funding ought to drive choices for a research project or stream," had suggestive evidence of loading on this factor. Because it cross-loaded, though, it was dropped.

Scientific Puritanism returned an alpha of .644. Further analysis of individual items and resultant alphas if particular items were removed showed the scale alpha could be improved to .691 if the item positing "Blind review is the only appropriate way to ensure that the best research is published" was removed. Yet, the alpha only changed marginally. With the item having a factor loading of just under .50 and clearly not loading on any other factors I argued for its inclusion in the subscale. Thus, although evidencing somewhat weaker statistical alignment with scientific Puritanism than the other three items, it is nonetheless a reasonable one, particularly given some insights from Merton (1973). According to Merton (1973), "pure science is. . . . seen as a defense against the invasion of norms that limit the directions of potential advance" (p. 260). This insight, combined with the acceptable statistical support, argues for its inclusion. The item captured the element of the norm related to prior knowledge and/or personal biases toward a researcher's personal characteristics not having a disparate impact on the advance of knowledge. As an example, if a peer reviewer held a personal bias against a researcher's personal background or his or her prior research, it could adversely affect the reviewer critique of the merits of the scholarship. *Scientific Puritanism* works to ensure this does not happen.

Communal Meritocracy returned an alpha of .250. The alpha for this scale was weak and, based on further analysis, removal of any items did not improve the scale. Based on the quantitative analysis, combined with the challenge of making sense of how they might hold together conceptually, it was clear that the possible scale was not reasonable and hence was removed.

A summary of the items included in the optimized instrument are shown in Table 14. To summarize, the *Organized Skepticism* and *Universalism* scales consisted of five items. The *Commercialism* and *Scientific Puritanism* scales consisted of four items each.

Table 14

The Four Factors and Their Respective Items

Organized Skepticism	Universalism	Commercialism	Scientific Puritanism
A researcher should be as skeptical of one's own findings as he/she is of others.	Generally, when peer reviewing for a publication within your field, it is important to know the lead author's country of origin.	Non-disclosure agreements are a reasonable tool for protecting research findings from being used by others for potential financial gain.	Science would benefit if more researchers chose to pursue projects based solely on the discovery of new knowledge free from considerations of personal benefit.
A researcher should seek evidence that contradicts his/her hypothesis.	The evaluation of a piece of research should consider the gender of the researcher.	It is appropriate to delay the submission of a piece of industry sponsored research for publication consideration so the firm can assess business implications.	Passion for discovery and not personal gain ought to be the driving force behind scientific endeavor.

Table 14 (continued)

Organized Skepticism	Universalism	Commercialism	Scientific Puritanism
Researchers ought to be skeptical of the findings of other researchers.	The institution that conferred a researcher's highest degree should be taken into consideration when evaluation scholarly contributions submitted to a peer reviewed journal.	The integration of confidentiality/non-disclosure language in contractual agreements between academic researchers for the sharing of research material, data, or findings is appropriate.	In general, the only rewards researchers should expect to receive as a result of their findings are recognition and esteem.
Regardless of how firmly a researcher is convinced of one's own ideas, he/she should take into account criticisms of those ideas by competent peers.	When reviewing a conference paper or journal manuscript it would be helpful if the reviewers knew something about the author.	It is appropriate to delay the publication of findings for 60 days while the findings are evaluated for possible patent protections.	Blind review is the only appropriate way to ensure that the best research is published.
It is important for a faculty member to highlight study limitations in any research he/she seeks to present or publish.	The evaluation of a piece of research should be based upon the quality of the work and not the track record of the researcher.		

Conclusion

Chapter 5 described the steps taken to conduct the factor analysis followed by an internal reliability procedure, the combined efforts resulting in a valid and reliable 18-item instrument. Chapter 6 discusses these results in light of recent work by Viale (2010a, 2010b) as well as offers some reflections on past, present, and future circumstances for the conduct of science. The chapter also discusses opportunities for further development of the instrument as well as opportunities for its use as an antecedent or outcome measure on issues related to scientific endeavor and institutional performance.

CHAPTER 6

Discussion

Chapter 5 presented the results the principal components extraction with a varimax rotation. The analysis and interpretation suggested a four-factor model with the components *Organized Skepticism, Universalism, Commercialism,* and *Scientific Puritanism*. Chapter 6 begins with a discussion of cognitive styles and scientific practice and how they aid in further understanding the results of this study. The chapter then extrapolates on the nature of the research enterprise in higher education in the past, present, and future and how the norms fit into that particular context. Chapter 6 concludes with a discussion of areas for further study and the limitations of the study.

Cognitive Styles and Scientific Practice

Although previous researchers have sought to develop instruments to measure norms of science, this study is among the first to attempt the development of a psychometrically sound instrument to measure faculty adherence to the norms of science. Furthermore, the study found strong evidence for two of Merton's (1973) original norms of science, *Organized Skepticism* and *Universalism*. The *Commercialism* and *Scientific Puritanism* scales revealed through the analysis, while somewhat akin to Merton's *communalism* and *disinterestedness* ideas, were nevertheless distinct and hence labeled differently. This finding suggests some changes have occurred in how faculty think about their work, possibly impacted by what is known about the entrepreneurial era of modern universities (Etzkowitz & Viale, 2010) and the triple helix of university—industry—government relations.

One helpful lens into these psychometric results is sourced in the theoretical work of Viale (2010a, 2010b). Viale argued that different cognitive styles impinge on the effective cooperation of academic scientists and industrial scientists. To summarize, background knowledge is represented by the set of rules, prescriptions, norms, and so on that impact the decision processes of both academic and industrial scientists. Because the background knowledge of academic scientists and industrial scientists is different, different cognitive styles could create barriers during research collaboration. Viale expanded his description of background knowledge to include ontic (mental models) and deontic (values, technical processes, methodologies, etc.) knowledge.

Viale (2010a, 2010b) expanded on Merton's social norms of science and included the operational norms of loose time versus pressing time, undefined results versus well-defined results, and financial lightness versus financial heaviness. Loose time constraints are attributed to academic science whereas pressing time constraints are attributed to industrial science. The other two operational norms related to results and funding are attributed thus: Undefined results and financial lightness are attributed to academic science. Of particular importance to the results of this instrument development study are the operational norms related to funding and results.

The operational norm of funding is represented by what was labeled the *Commercialism* scale. Viale (2010a, 2010b) identified the operational norm of funding not as one pertaining to the amount of funding but rather as one pertaining to the psychological importance of funding and how it plays into the decision processes of scientists, both academic and industrial. Viale stated that academic scientists will place less weight on the value of money and how it affects their decision processes whereas industrial scientists will be more greatly impacted in their decisions by the psychological value of money. Items in the *Commercialism* scale seem to have captured the operational norm related to funding, especially as the items relate to decisions made in response to financial gain, business implications, and sources of funding.

The scale of *Scientific Puritanism* relates to the operational norm of undefined results versus well-defined results. Viale (2010a, 2010b) described this operational norm as a difference in ontology of the output of the research. Whereas academic scientists seek to explain and embody the results of the research in a linguistic representation like scholarly articles or conference presentations, industrial scientists work toward ontology of the object. Whether the object is a widget, molecule, or even an improved process that could be patented, the industrial scientist works to produce something tangible and immediately salable. Items in the *Scientific Puritanism* scale point to the generation of new knowledge as an end in itself where blind review is an appropriate way to ensure the best research is published.

Norms of Science: Past, Present, and Future

Throughout the past 100 years the research enterprise in higher education has gone through dramatic changes. As was explained in the literature review of this dissertation, during the late 19th century, the German model for basic research and the extension of knowledge was adopted in the United States, first by Johns Hopkins University and later other institutions (Boyer, 1990). Although basic research was more the exception rather than the rule prior to 1940, World War II changed everything. The government and American higher education pulled together to win the war. Faculty began to be viewed primarily as researchers rather than just teachers (Boyer, 1990).

In 1942 when Merton (1973) first published his normative structure of science in the *Journal of Legal and Political Sociology*, the nature of the relationship between the university, industry, and higher education was already changing. The Office of Scientific Research and Development had entered into research agreements with universities and industry. MIT received 75 contracts for a total of $866 million in 1996 dollars (Mowery et al., 2004). In summary, the roots of close university–government–industry relationships were taking hold.

In light of this change a distinction should be drawn between two types of research and their interplay with the normative structure of science as it was introduced by Merton (1973). Stehr (1978) reiterated an argument in the literature that critiqued Merton's theory. It was argued that Merton's norms of science might in fact be the prescribed ideal normative structure for pure science but not necessarily applied science. Merton first published his theory in 1942 and since then the major shift in research has been toward federal funding of research that would generate findings that could be applied to particular government missions (Mowery et al., 2004). Science and research had moved in the direction of application of new knowledge. While the norms of science might have been a theoretically sound prescription for pure science, there was growing evidence of a shift toward universities being viewed as engines of economic development (Blumenstyk, 2010) that today arguably paints Merton's normative structure of science as quaint nostalgia for a time long past.

Etzkowitz and Viale (2010) argued that new knowledge will be increasingly polyvalent with "theoretical, practical and interdisciplinary implications forming a common center of gravity" (p. 596). Knowledge will take on new integrated forms like "nanobio, biocogninano, infocogni" and "traditional academic disciplinary borders will disappear" (Etzkowitz & Viale, 2010, p. 601). The new context about which Etzkowitz and Viale have so recently written requires researchers to be able to understand multiple frameworks as well as have an ability to see the practical application of their theory. This requirement could cause a cognitive overload. The answer to this cognitive overload is a need for greater collaboration between disciplines as well as between industry and universities. The scenario could be such that interdisciplinary scientists focus on either pure science or applied (innovative) science or both, but at different stages in their careers. Regardless, the transition continues to bring pure (academic) and applied (industry) scientists together. Etzkowitz and Viale (2010) argued there is and will be a convergence of epistemological and methodological norms "between academy (industrialization of science) and industry (scientification of industry)" (p. 600). It will remain important to operationalize norms of practice within these developing paradigms of practice, a phenomenon on which this study has focused.

Opportunities for Future Research

To summarize, this study produced a valid and reliable instrument that includes scales that measure the Mertonian norms of science of *Organized Skepticism* and *Universalism*. Elements of the *Commercialism* and *Scientific Puritanism* scales share commonalities with Viale's (2010a) operational norms of funding and results. While an obvious next step in putting these scales into practice includes further refining the instrument and utilizing confirmatory factor analysis to verify construct validity, it also includes using as a jumping off point the argument of Etzkowitz and Viale (2010) related to industrial and scientific normative convergence. Although the arguments as mentioned earlier are sound and rooted in exhaustive scholarly work, the next step in extending their theory is to empirically test for the convergence of norms.

As an example of empirically validating normative convergence, a longitudinal study could be conducted that would follow a sample of doctoral students in the life sciences. A semi-structured interview plus the norms of science instrument would be administered upon their entering the doctoral program. It would be important to select participants both who had substantial industry collaboration throughout their doctoral studies and early academic career as well as those who had little to no industry collaboration. An annual assessment would be scheduled to capture the progress of the participant through the doctoral pipeline, the participant's level of industry collaboration, publications, patents, and potential work with inventions that generated a spin-off company. At three years into the participant's post-Ph.D. academic career, a semi-structured follow-up interview would be scheduled and the norms of science instrument would be administered a second time. The research question would be an investigation into the effect of doctoral training and industry–research collaboration on the attitudes of academic life scientists toward the prescribed norms of science identified in this study.

In the interim, a similar study could be performed utilizing a random sample of life scientists at research universities around the United States. The refined norms of science survey would be administered while a series of background items would collect self-reported data similar to that used in this dissertation. A major difference would be the use of institutional data as a proxy for entrepreneurial activity. This study utilized self-reported patent activity as an indicator of entrepreneurial activity. If one uses patent activity as a proxy for entrepreneurial behavior, this study suggests that those researchers listed on at least one patent might identify more with the counter-normative side of the scale when responding to the item, "It is appropriate to delay the submission of a piece of industry sponsored research for publication consideration so the firm can assess business implications." An exploratory test of the data collected in this study found empirical support of a difference in this regard (faculty with patents, M = 4.37, faculty without patents, M = 3.79, p = .001).

Relatedly, it would be informative to request self-reported data regarding spin off company creation at the individual unit of analysis while using data from the AUTM to provide a proxy for entrepreneurial activity at the institutional level. In both instances, regression analysis could provide deeper insight into what impact attitudinal adherence to the norms of science has on entrepreneurial activity. Using the same methodology, entrepreneurial activity operationalized as patent and invention disclosure activity could be used as an independent variable to predict the outcomes of participant *Organized Skepticism, Universalism,* and *Commercialism* scale scores.

Another area for potential research is the ability to use the scales to control for the social norms of *Organized Skepticism* and *Universalism*. Viale's (2010a, 2010b) thesis introduced a stream of research that investigated the role of cognitive differences in the collaboration between academic and industrial scientists. Scholarship on the norms of science has been inadequate in providing the tools necessary for Viale's inquiry. "The state of the art of studies on social norms in academic and industrial research seems insufficient and empirically obsolete. A new study of norms contained in background knowledge is essential" (Viale, 2010b, p. 48). New research such as what Viale suggests is needed so as to control for the main features characterizing the cultural identity of academic and industrial researchers. The scale development work reported in this study can provide that control. Said another way, the scales can be put into practice as a control for the norms of science in research that studies the broader implication of cognitive models and background knowledge on the interaction between industry and academic scientists.

Limitations

Although this study developed and validated an instrument to measure faculty adherence to particular norms of science, there are limitations to the study that must be addressed. First, some of the alphas of the instrument and its subscales were below .70, the most commonly acceptable cut-off. While they might have been higher, given that factor analysis and reliability work are at least one part art tied to statistical science the results are nevertheless reasonable.

Second, this study used a convenience sample from the Midwest of the United States. While the sample size and response rate were more than adequate, the findings of the study cannot necessarily be generalized to the population of academic scientists at all research universities. In other words, the results of the study could be geographically bounded.

Third, this study treated the social norms of science, in some respects, as behavioral norms when in fact they can also be viewed purely as norms of discourse. Using the work of Viale (2010a) as a frame of reference and what he determined to be operational norms of science, it can be inferred that some items in this instrument were worded as norms along the lines of research and commercialization activity, or operations, instead of a more general and ephemerally worded item more in-line with the characteristics of a social norm. Though this might be a current limitation for this study, it is not a limitation for furthering the study of the norms or in using those particular items in follow-up studies. In the future, more strict definitions should be considered to separate the social norms from norms indicative of the operations of the research complex.

Finally, norms can be a subjective component of organization phenomena and hence are notoriously difficult to measure accurately. While this study surfaced scales that held together well, there are likely norm components not captured by the research. Norms may also be situational, and all nuances of scientific endeavor were not captured in the instrument.

Conclusion

The purpose of this study was to develop a psychometrically reliable and valid instrument to measure faculty adherence to the norms of science. The study achieved this objective, namely to produce an instrument that measures adherence to the scientific norms of *Organized Skepticism, Universalism, Commercialism,* and *Scientific Puritanism*. Although the instrument is not exhaustive in its measurement of all the nuances found within the normative structure of science, its ability to control for the norms it measures has been tested and found to be adequate. As it is put into use, it can provide deeper understanding into faculty and their interaction within the triple helix of university–industry–government relations (Etzkowitz et al., 2000).

References

Altbach, P. G. (2005a). Harsh realities: The professoriate faces a new century. In P. G. Altbach, R. O. Berdahl, & P. J. Gumport (Eds.), *American higher education in the twenty-first century: Social, political, and economic challenges* (pp. 287-314). Baltimore, MD: Johns Hopkins University Press.

Altbach, P. G. (2005b). Patterns in higher education development. In P. G. Altbach, R. O. Berdahl & P. J. Gumport (Eds.), *American higher education in the twenty-first century: Social, political, and economic challenges* (pp. 15-37). Baltimore, MD: Johns Hopkins University Press.

Andersen, H. (2001). The norm of universalism in sciences: Social origin and gender of researchers in Denmark. *Scientometrics, 50,* 255-272.

Anderson, M. (2000). Normative orientations of university faculty and doctoral students. *Science and Engineering Ethics, 6,* 443-461. doi: 10.1007/s11948-000-0002-6

Anderson, M. H. (2006). How can we know what we think until we see what we said? A citation and citation context analysis of Karl Weick's the social psychology of organizing. *Organization Studies, 27,* 1675-1692. doi:10.1177/0170840606068346

Anderson, M. S., Martinson, B. C., & De Vries, R. (2007). Normative dissonance in science: Results from a national survey of U.S. scientists. *Journal of Empirical Research on Human Research Ethics, 2*(4), 3-14. doi:10.1525/jer.2007.2.4.3

Anderson, M. S., Ronning, E. A., De Vries, R., & Martinson, B. C. (2010). Extending the Mertonian norms: Scientists' subscription to norms of research. *Journal of Higher Education, 81,* 366-393.

Association of University Technology Managers. (2008). *U.S. licensing activity survey: FY2007*. Retrieved from http://www.autm.net/AM/Template.cfm?Section= FY_2007_Licensing_Activity_Survey

Association of University Technology Managers. (2009). *U.S. licensing activity survey: FY2008*. Retrieved from http://www.autm.net/AM/Template.cfm?Section=FY_2007_Licensing_Activity_Survey &CONTENTID=4208&TEMPLATE=/CM/ContentDisplay.cfm

Baldini, N. (2009). Implementing Bayh-Dole-like laws: Faculty problems and their impact on university patenting activity. *Research Policy*, *38,* 1217-1224. doi:10.1016/j.respol.2009.06.013

Blumenstyk, G. (2010, March 12). Forum highlights ways to tune up universities as engines of economic development, proceeding. *Chronicle of Higher Education*, online edition, A22. Retrieved from http://ezproxy.indstate.edu:2048/login?url- http://search.ebscohost.com/login.aspx?direct=true&db=f5h&AN=48758458&site=ehos t-live

Boni, A., & Emerson, S. (2005). An integrated model of university technology commercializatoin and entrepreneurship education. In G. Libecap (Ed.), *University entrepreneurship and technology transfer: Process, design, and intellectual property* (pp. 241-274). Amsterdam, Netherlands: Elsevier.

Boyer, E. L. (1990). *Scholarship reconsidered: Priorities of the professoriate*. Princeton, NJ: Carnegie Foundation for the Advancement of Teaching.

Braxton, J. M. (1986). The normative structure of science: Social control in the academic profession. In J. C. Smart (Ed.), *Higher education: Handbook of theory and research* (Vol. II, pp. 309-357). New York, NY: Agathon Press.

Braxton, J. M. (1990). Deviancy from the norms of science: A test of control theory. *Research in Higher Education, 31*, 461-476.

Braxton, J. M. (1993). Deviancy from the norms of science: The effects of anomie and alienation in the academic profession. *Research in Higher Education*, *34,* 213-228. doi:10.1007/BF00992162

Braxton, J. M. (Ed.). (1999). *Perspectives on scholarly misconduct in the sciences*. Columbus, OH: Ohio State University Press.

Braxton, J. M., & Baird, L. L. (2001). Preparation for professional self-regulation. *Science and Engineering Ethics, 7,* 593-610.

Bray, N. J. (2010). The deanship and its faculty interpreters: Do Mertonian norms of science translate into norms for administration? *Journal of Higher Education, 81*, 284-316.

Cheslock, J., & Gianneschi, M. (2008). Replacing state appropriations with alternative revenue sources: The case for voluntary support. *The Journal of Higher Education*, *79,* 208-229.

Cohen, J. (2001). *Shots in the dark: The wayward search for an AIDS vaccine*. New York, NY: Norton.

Collins, B. (2010). Inventor's bill of rights. *Inventors' Digest, 26*(6), 34.

Commercialization of University Research Request for Information. 75 Fed. Reg. 14476 (2010).

Cook-Deegan, R. (2007). The science commons in health research: Structure, function, and value. *Journal of Technology Transfer*, *32*(3), 133-156.

Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment, Research & Evaluation, 10*(7), 1-9.

Dai, Y., Popp, D., & Bretschneider, S. (2005). Institutions and intellectual property: The influence of institutional forces on university patenting. *Journal of Policy Analysis and Management, 24*, 579-598.

DeVellis, R. F. (2003). *Scale development: Theory and applications*. Thousand Oaks, CA: Sage.

DeVol, R., Bedroussian, A., Babayan, A., Frye, M., Murphy, D., Philipson, T. J., Wallace, L., Wong, P., & Yeo, B. (2006). *Mind to market: A global analysis of university biotechnology transfer and commercialization.* Santa Monica, CA: Milken Institute.

Dillman, D. A. (2007). *Mail and internet surveys: The tailored design method*. Hoboken, NJ: John Wiley & Sons.

Etzkowitz, H., & Leydesdorff, L. (1999). The future location of research and technology transfer. *Journal of Technology Transfer, 24*(2-3), 111-123.

Etzkowitz, H., & Viale, R. (2010). Polyvalent knowledge and the entrepreneurial university: A third academic revolution? *Critical Sociology, 36*, 595-609.

Etzkowitz, H., Webster, A., Gebhardt, C., & Terra, B. R. C. (2000). The future of the university and the university of the future: Evolution of ivory tower to entrepreneurial paradigm. *Research Policy, 29*(2), 313-330. doi:10.1016/S0048-7333(99)00069-4

Fanelli, D. (2009). How many scientists fabricate and falsify research? A systematic review and meta-analysis of survey data. *PLoS ONE, 4*(5), e5738.

Field, A. (2005). *Factor analysis in SPSS.* Retrieved from http://www.statisticshell.com/factor.pdf

Friedman, J., & Silberman, J. (2003). University technology transfer: Do incentives, management, and location matter? *Journal of Technology Transfer, 28*(1), 17-30.

Golob, E. (2006). Capturing the regional economic benefits of university technology transfer: A case study. *Journal of Technology Transfer, 31,* 685-695.

Goode, W. J. (1957). Community within a community: The professions. *American Sociological Review, 22*(2), 194-200.

Graff, G., Heiman, A., & Zilberman, D. (2002). University research and offices of technology transfer. *California Management Review, 45*(1), 88-115.

Grassmuc, K. (1991, June 12). Gatorade brings U. of Florida $17-Million—and 5 court actions. *Chronicle of Higher Education, 37*(39), A25-A26.

Heher, A. D. (2006). Return on investment in innovation: Implications for institutions and national agencies. *Journal of Technology Transfer, 31,* 403-414.

Jones, M. P. (2009). Entrepreneurial science: The rules of the game. *Social Studies of Science, 39,* 821-851. doi: 10.1177/0306312709104434

Kluger, J. (2006). *Splendid solution: Jonas Salk and the conquest of polio*. New York, NY: Berkley Books.

Lach, S., & Schankerman, M. (2004). Royalty sharing and technology licensing in universities. *Journal of the European Economic Association, 2,* 252-264. doi:10.1162/154247604323067961

Link, A. N., & Siegel, D. S. (2005). Generating science-based growth: An econometric analysis of the impact of organizational incentives on university–industry technology transfer. *The European Journal of Finance, 11*, 169-181.

MacFarlane, B., & Cheng, M. (2008). Communism, universalism and disinterestedness: Re-examining contemporary support among academics for Merton's scientific norms. *Journal of Academic Ethics, 6*(1), 67-78.

Markman, G. D., Gianiodis, P. T., Phan, P. H., & Balkin, D. B. (2004). Entrepreneurship from the ivory tower: Do incentive systems matter? *Journal of Technology Transfer, 29,* 353-364.

Markman, G. D., Phan, P., Balkin, D., & Gianiodis, P. (2005). Entrepreneurship and university-based technology transfer. *Journal of Business Venturing, 20*, 241-263.

Mertler, C. A., & Vannatta, R. A. (2002). *Advanced and multivariate statistical methods: Practical application and interpretation*. Los Angeles, CA: Pyrczak.

Merton, R. K. (1968). *Social theory and social structure*. New York, NY: Free Press.

Merton, R. K. (1973). *The sociology of science: Theoretical and emperical investigations*. Chicago, IL: University of Chicago Press.

Merton, R. K., & Sztompka, P. (1996). *On social structure and science*. Chicago, IL: University of Chicago Press.

Mitroff, I. (1974). Norms and counter-norms in a select group of the Apollo moon scientists: A case study of the ambivalence of scientists. *American Sociological Review, 39*, 569-595.

Mowery, D. C. (2005). The Bayh-Dole act and high-technology entrepreneurship in U.S. universities: Chicken, egg, or something else? In G. Libecap (Ed.), *University entrepreneurship and technology transfer: Process, design, and intellectual property* (pp. 39-68). Amsterdam, Netherlands: Elsevier.

Mowery, D. C., Nelson, R. R., Sampat, B. N., & Ziedonis, A. A. (2004). *Ivory tower and industrial innovation: University-industry technology transfer before and after the Bayh-Dole act in the United States*. Stanford, CA: Stanford Business Books.

Owen-Smith, J., & Powell, W. W. (2001). To patent or not: Faculty decisions and institutional success at technology transfer. *Journal of Technology Transfer*, *26*(1-2), 99-114.

Powers, J. (2000). *Academic entrepreneurship in higher education: Institutional effects on performance of university technology transfer*. Available from ProQuest Dissertations and Theses database. (ProQuest document ID: 728402101)

Powers, J. (2003). Commercializing academic research: Resource effects on performance of university technology transfer. *The Journal of Higher Education*, *74*, 26-50.

Powers, J., & Campbell, E. (2009). University technology transfer in tough economic times. *Change, 41*(6), 43-47.

Renault, C. (2006). Academic capitalism and university incentives for faculty entrepreneurship. *Journal of Technology Transfer*, *31*, 227-239.

Rothaermel, F., Agung, S., & Jiang, L. (2007). University entrepreneurship: A taxonomy of the literature. *Industrial and Corporate Change*, *16*, 691-791.

Rudolph, F. (1990). *The American college and university: A history*. Athens, GA: University of Georgia Press.

Siegel, D., & Phan, P. (2005). Analyzing the effectiveness of university technology transfer: Implications for entrepreneurship education. In G. Libecap (Ed.), *University entrepreneurship and technology transfer: Process, design, and intellectual property* (pp. 1-38). Amsterdam, Netherlands: Elsevier.

Slaughter, S., & Rhoades, G. (2005). Markets in higher education: Students in the seventies, patents in the eighties, copyrights in the nineties. In P. G. Altbach, R. O. Berdahl & P. J. Gumport (Eds.), *American higher education in the twenty-first century: Social, political, and economic challenges* (pp. 486-516). Baltimore, MD: Johns Hopkins University Press.

Standish-Kuon, T. (2007). *Gray matters: Understanding academic researchers' decisions about commercializaing their ideas and discoveries*. Available from ProQuest Dissertations and Theses database. (ProQuest document ID: 1472128461)

Stehr, N. (1978). The ethos of science revisited. *Sociological Inquiry, 48,* 172-196.

Sztompka, P. (2007). Trust in science: Robert K. Merton’s inspirations. *Journal of Classical Sociology, 7,* 211-220. doi:10.1177/1468795x07078038

Tabachnick, B. G., & Fidell, L. S. (2000). *Using multivariate statistics*. Boston, MA: Allyn & Bacon.

Thelin, J. R. (2004). *A history of American higher education*. Baltimore, MD: Johns Hopkins University Press.

Thursby, J. G., & Thursby, M. C. (2002). Who is selling the ivory tower? Sources of growth in university licensing. *Management Science, 48*(1), 90-104.

Turk-Bickakci, L., & Brint, S. (2005). University-industry collaboration: Patterns of growth for low- and middle-level performers. *Higher Education*, *49,* 61-89.

U. of Florida gulps Gatorade profits. (2002). *The Chronicle of Higher Education, 48*(34), A27.

Ulrich, D., & Barney, J. B. (1984). Perspectives in organizations: Resource dependence, efficiency, and population. *Academy of Management Review, 9*, 471-481.

Van Horn, P., Green, K., & Martinussen, M. (2009). Survey response rates and survey administration in counseling and clinical psychology. *Educational and Psychological Measurement, 69,* 389-403.

Viale, R. (2010a). Different cognitive styles in the academy–industry collaboration. In L. Magnani, W. Carnielli, & C. Pizzi (Eds.), *Model-based reasoning in science and technology* (Vol. 314, pp. 83-105). Berlin, Germany: Springer.

Viale, R. (2010b). Knowledge-driven capitalization of knowledge. In R. Viale & H. Etzkowitz (Eds.), *The capitalization of knowledge: A triple helix of university–industry–government* (pp. 31-73). Cheltenham, UK: Edward Edgar Publishing Limited.

Wright, M., Birley, S., & Mosey, S. (2004). Entrepreneurship and university technology transfer. *Journal of Technology Transfer, 29,* 235-246.

Ziman, J. (2000). *Real science: What it is and what it means*. Cambridge, MA: Cambridge University Press.

Appendix A: Items Used In Studying Norms of Science

Source	Norm	Item
Ladd and Lipset, as cited in Braxton (1990; 1993)	Communality	In general, scientists and scholars are unjustified in keeping their research findings secret.
		Scientists and scholars have the obligation to acknowledge intellectual property by pertinent citations and references.
		Scientists and scholars should be willing to inform others investigating similar problems about their work in progress.
	Disinterestedness	Scientists and scholars should prefer critical evaluation by competent peers to public acclaim.
	Organized Skepticism	Scientists and scholars should critically examine others' contributions that they are using in their own work.
		Scientists and scholars should be skeptical even about their own research findings until competent peers have evaluated them.
		Scientists and scholars have an obligation to present available evidence that contradicts their hypotheses.
		No matter how deeply persuaded scientists and scholars may be that their ideas are sound, they must take account of critical appraisals of these ideas by competent peers.

Source	Norm	Item
		Scientists and scholars ought to question their findings if these cannot be independently reproduced by any others in the field.
	Universalism	The acceptance or nonacceptance of scientific and scholarly contributions should be judged on the evidence and not on the social characterstics [such as race or sex] of the authors.
		The standing accorded scientists and scholars in their fields should depend on the quality and extent of their contributions, not on their personal or social characteristics.
Anderson (2000; 2007; 2010)	Universalism	Scientists evaluate research only on its merit, i.e., according to accepted standards of the field.
	Communality	Scientists openly share new findings with all colleagues.
	Disinterestedness	Scientists are motivated by the desire for knowledge and discovery, and not by the possibility of personal gain.
	Organized Skepticism	Scientists consider all new evidence, hypotheses, theories, and innovations, even those that challenge their own work.
	Particularism	Scientists assess new knowledge and its applications based on the reputation and past productivity of the individual or research group.
	Individualism/ Secrecy	Scientists protect their newest findings to ensure priority in publishing, patenting, or applications.
	Self-interestedness	Scientists compete with others in the same field for funding and recognition of their achievements.

Source	Norm	Item
	Organized dogmatism	Scientists invest their careers in promoting their own most important findings, theories, or innovations.
Macfarlane and Chang (2008)	Communism	. . . in favor of sharing teaching materials with peers and results of their research in progress.
	Secrecy/ Individualism	I tend to be secretive about my research in progress as I am concerned that someone else may beat me to publication.
	Communism	As far as possible, I try to ensure that my intellectual work is not influenced by my personal beliefs and values.
	Universalism	I think the extent to which research may be generalisable or valid beyond its immediate context is important.
	Disinterestedness	I align my research interests with funding opportunities.
		I only pursue research that is of personal interest to me.

Appendix B: The Web-Based Instrument

Indiana State University
More. From day one.

Default Question Block

ACADEMIC SCIENCE, FACULTY, AND THE NORMS OF SCIENCE

You were selected to participate in this study because of your status as a faculty member and researcher in the scientific disciplines of engineering, physics, chemistry, or medicine.

There are no known risks or costs to participating. The information you provide will be used in quantitative analyses and in particular exploratory and confirmatory factor analyses. The analyses will deepen understanding of particular norms of science and how they manifest. The survey instrument will take approximately 6 to 8 minutes to complete. Information collected may not benefit you directly, but it may have general benefits to knowledge for informing the research enterprise.

This electronic survey administered through Qualtrics is anonymous and no personally identifiable information will be collected. Your responses will not be linked to your e-mail address nor tracked by the researcher. When you have completed the survey, the use of automated links allows the system to remove you from e-mail reminders. Additionally, upon completion of the survey you will be given access to the summary results of the study so that you can see how others have responded. The summary data will be deactivated on July 1, 2011. Indiana State University's Institutional Review Board may inspect these records. Should the data be published, no individual information will be disclosed.

By having clicked through to the survey, you indicate your agreement to participate. You may decline to answer any question you do not wish to answer for any reason.

If you have any questions about the study, please contact Eric D. Motycka at 812-514-8450 or eric.motycka@indstate.edu.

If you have any questions about your rights as a research subject or if you feel you've been placed at risk, you may contact the Indiana State University Institutional Review Board (IRB) by mail at Indiana State University, Office of Sponsored Programs, Terre Haute, IN, 47809, by phone at (812) 237-8217, or by e-mail at irb@indstate.edu.

Contact information for researcher:
Eric D. Motycka MBA, PMP
Indiana State University
Office: (812) 514-8450
E-mail: eric.motycka@indstate.edu

Block 1

Please take a moment to reflect on the following statements and then note your level of agreement or disagreement.

	Strongly Agree	Agree	Somewhat Agree	Somewhat Disagree	Disagree	Strongly Disagree
1. Researchers should openly share findings with colleagues.	○	○	○	○	○	○
2. The integration of confidentiality/non-disclosure language in contractual agreements between academic researchers for the sharing of research material, data, or findings is appropriate.	○	○	○	○	○	○
3. It is appropriate to delay the submission of a piece of industry sponsored research for publication consideration so the firm can assess business implications.	○	○	○	○	○	○
4. It is appropriate to delay the publication of findings for 60 days while the findings are evaluated for possible patent protections.	○	○	○	○	○	○
5. Research outcomes are not something that anyone "owns" but rather should be made freely available upon request.	○	○	○	○	○	○
6. Non-disclosure agreements are a reasonable tool for protecting research findings from being used by others for potential financial gain.	○	○	○	○	○	○

Block 2

Please take a moment to reflect on the following statements and then note your level of agreement or disagreement.

Strongly Agree	Agree	Somewhat Agree	Somewhat Disagree	Disagree	Strongly Disagree

1. The evaluation of a piece of research should be based upon the quality of the work and not the track record of the researcher.

○ ○ ○ ○ ○ ○

2. Blind review is the only appropriate way to ensure that the best research is published.

○ ○ ○ ○ ○ ○

3. A researcher's grants and scholarship record is as important a consideration when evaluating a grant proposal as the merit of the research proposed.

○ ○ ○ ○ ○ ○

4. The institution that conferred a researcher's highest degree should be taken into consideration when evaluating scholarly contributions submitted to a peer-reviewed journal.

○ ○ ○ ○ ○ ○

5. During the peer review process, a reviewer should be aware of the lead author's past publications.

○ ○ ○ ○ ○ ○

6. The evaluation of a piece of research should consider the gender of the researcher.

○ ○ ○ ○ ○ ○

7. Generally, when peer reviewing for a publication within your field, it is important to know the lead author's country of origin.

○ ○ ○ ○ ○ ○

8. When reviewing a conference paper or journal article manuscript it would be helpful if the reviewers knew something about the author(s).

○ ○ ○ ○ ○ ○

Block 3

Please take a moment to reflect on the following statements and then note your level of agreement or disagreement.

Strongly Agree	Agree	Somewhat Agree	Somewhat Disagree	Disagree	Strongly Disagree

1. The possibility of public and media acclaim for one"s research is an important consideration when starting a research project or direction of inquiry.

2. The likelihood of achieving tenure is enhanced when a researcher pursues a scholarly stream that has consulting or revenue potential from the outcomes of that research.

3. Passion for discovery and not personal gain ought to be the driving force behind scientific endeavor.

4. In general, the only rewards researchers should expect to receive as a result of their findings are recognition and esteem.

5. Opportunities for funding ought to drive choices for a research project or stream.

6. Science would benefit if more researchers chose to pursue projects based solely on the discovery of new knowledge free from considerations of personal benefit.

Block 4

Please take a moment to reflect on the following statements and then note your level of agreement or disagreement.

	Strongly Agree	Agree	Somewhat Agree	Somewhat Disagree	Disagree	Strongly Disagree
1. Researchers ought to be skeptical of the findings of other researchers.	○	○	○	○	○	○
2.A researcher should be as skeptical of one's own findings as he/she is of others.	○	○	○	○	○	○
3.A researcher should seek evidence that contradicts his/her hypotheses.	○	○	○	○	○	○
4. Regardless of how firmly a researcher is convinced of one's own ideas, he/she should take into account criticisms of those ideas by competent peers.	○	○	○	○	○	○
5.It is important for a faculty member to highlight study limitations in any research he/she seeks to present or publish.	○	○	○	○	○	○

Background Information

What best describes your academic discipline?

- ◯ Engineering
- ◯ Physics
- ◯ Chemistry
- ◯ Medicine
- ◯ Other

What best describes your academic rank?

- ◯ Assistant Professor
- ◯ Associate Professor
- ◯ Professor
- ◯ Instructor or Lecturer
- ◯ Adjunct Faculty
- ◯ Other

What is your gender?

- ◯ Male
- ◯ Female

Are you listed as an inventor on at least one patent application or patent issue?

- ◯ Yes
- ◯ No

In which country were you born?

What is the number of years you have been in academia since completing your degrees? Please use the space below to enter a number.

What is the number of peer-reviewed journal articles on which you have been at least a contributing author?

What is the number of industry sponsored projects on which you have been the principal investigator?

Appendix C: Communication Pieces

Initial Invitation E-mail

Dear Dr. ${m://LastName}

My name is Eric D. Motycka, a doctoral candidate at Indiana State University conducting a dissertation study on the culture of academic science among faculty researchers at R1 universities. It is being conducted under the direction of Dr. Joshua Powers, Holmstead Distinguished Professor in the Bayh College of Education. The specific intent of the study is the validation of a psychometrically sound instrument for measuring particular norms and beliefs that can then be used to explore their antecedents and outcomes. The instrument is ultimately envisioned to inform such topics as how emerging scholars are socialized, how tenure and promotion mechanisms are utilized for the alignment of researcher and institutional goals, and more broadly, the conduct of basic and applied science.

As an active researcher in the sciences, I am hopeful you would complete the survey that I will be sending out via an email link in about a week. The Qualtrics administered email you receive will be from noreply@qemailserver.com. If you wish to participate please designate this email address as a safe sender in your email settings. The survey is anonymous, has 25 questions, and should take no more than 6-8 minutes to complete. In appreciation of your participation, you would be entered into a drawing to win a WiFi enabled 16 GB iPad 2.
Thank you for your consideration.

Sincerely,

Eric D. Motycka MBA, PMP
Indiana State University
Terre Haute, IN 47809
eric.motycka@indstate.edu; 812-514-8450

E-mail with Survey Link

Hello Dr. ${m://LastName}:

I am writing in reference to the Academic Science and Faculty Culture survey in which you have been invited to participate. The initial invitation came to you last week. After participating in the study you will be given access to the study's public summary data and also be included in the opportunity to receive the 16GB WiFi enabled iPad 2.

Thank you so much again for your time and cosideration and all the best to you and your colleagues as you bring the Spring 2011 semester to a close.

Sincerely,

Eric D. Motycka MBA, PMP
Doctoral Candidate
Indiana State University
Bayh College of Education

Follow this link to the Survey:
${l://SurveyLink?d=Take the Survey}

Or copy and paste the URL below into your internet browser:
${l://SurveyURL}

Follow the link to opt out of future emails:
${l://OptOutLink}

Reminder E-mail

Greetings Dr. ${m://LastName}:

First of all, thank you for your patience as my requests have come to your inbox. Regarding the invitation to participate in the Academic Science and Faculty Culture survey, this will be the last reminder you will receive. Data collection will stop on May 1st, 2011. While the response rate for this study has been adequate, more responses will further strengthen the results be presented at the 9th Triple Helix International Conference being held at Stanford in July, 2011. Your input is both important and appreciated.

The randomized selection of the participant to receive the 16 GB WiFi enabled iPad 2 will take place the second week of May 2011.

Thank you again for your patience and your time.

Sincerely,

Eric D. Motycka MBA, PMP
Doctoral Candidate
Bayh College of Education
Indiana State University

Follow this link to the Survey:
${l://SurveyLink?d=Take the Survey}

Or copy and paste the URL below into your internet browser:
${l://SurveyURL}

Follow the link to opt out of future emails:
${l://OptOutLink}

Thank You E-Mail

Thank you Dr. ${m://LastName}:

Your participation is appreciated and the e-mail used to contact you has been entered into a drawing to win a WiFi enabled 16 GB iPad 2. The drawing will take place during the 2nd week of May, 2011 and the winner will be notified via e-mail. Delivery instructions will be requested at that time.

Please select the following link to be taken to the public summary results of this study.

Summary Link: https://indstate.qualtrics.com/CP/Report.php?RP=RP_eJ6BmYlldLLW5Mw

Password for Summary Page: motycka

Thank you so much again for your time and for your participation.

Sincerely,

Eric D. Motycka MBA, PMP
Indiana State University
eric.motycka@indstate.edu