Development of an Instrument to Measure Faculty Adherence to the Norms of Science

Subtheme 2.2: Enabling Conditions for Transfer
Triple Helix IX International Conference
11-14 July 2011; Stanford University

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Keywords: Norms of Science, Entrepreneurial Science, Triple Helix

 This paper is based on a dissertation conducted by the first author under the supervision of the second author.

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 of faculty and the norms of science, there is still some ambiguity in measuring faculty adherence to the norms with psychometric reliability and validity. The goal of this paper is to contribute to the literature by developing a valid and reliable instrument to measure faculty adherence to the norms of science. This instrument differentiates between the norms of *Organized Skepticism, Universalism, Commercialism,* and *Scientific Puritanism.* The instrument's psychometric properties demonstrate both construct validity and internal reliability and have been tested on 290 faculty at United States Midwestern research universities.

Keywords: Norms of Science, Entrepreneurial Science, Triple Helix

The *Chronicle of Higher Education* reported that as part of President Obama's initiative to turn around the United States economy, his administration is exploring how universities can better perform as engines of economic development (Blumenstyk, 2010). On March 25th, 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, pp. 14,777). 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 as 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 (Henry Etzkowitz & Leydesdorff, 1999). In viewing current events through the lens of 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 has been suggested by Sztompka (2007) to upend the scientific ethos. Sztompka rooted his argument in the four norms of academic science prescribed by Merton (1973): Communalism, universalism, disinterestedness and organized skepticism. Sztompka argued that mid to late 20th century science saw changes that included the need for external agencies and resources to fund ever more expensive research and the need for privatization of research in which more findings are owned by sponsoring organizations. Stzompka points to the commodification of science where scientific findings had become a marketable item, science had become bureaucratized, and there existed a "diminishing exclusiveness and autonomy of the scientific community" (p. 218-219). Etzkowitz and Viale (2010) viewed the transition as the third academic revolution where there "is a convergence of methodological and epistemological aims and norms between academy (industrialization of science) and industry (scientification of industry)" (p. 600). Both views use as a frame the norms of science. While cited extensively in literature pertaining to research policy and research ethics, at the conception of this study, the norms of science still lacked a reliable and valid method of measurement.

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 (M. Anderson, 2000; M. S. Anderson, Martinson, & De Vries, 2007; Macfarlane & Cheng, 2008; Renault, 2006). This stream of literature has illuminated gaps and the 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). Furthermore, according to an extensive literature review that covered 173 articles published between 1981 to 2005 studying university entrepreneurship, 71% were descriptive in nature and not theory-driven (Rothaermel, Agung, & Jiang, 2007). Hence, while a strong foundation exists that has focused on the academic entrepreneurship phenomena, more is needed to develop robust measures of it.

This paper sought to help fill the measurement gap. Pulling from classical measurement theory and utilizing exploratory factor analysis, this paper will describe the process used to develop a valid and reliable instrument to measure faculty adherence to the norms of science. Such an 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.

Review of the Literature

Norms of Science

This section of the review of the literature discusses the four scientific norms of communism (communalism), universalism, disinterestedness, and organized skepticism (Merton, 1973) given their centrality to instrument development and one continuum of the norms of science. Based on Barber's recommendations (as cited in Braxton, 1985), the term communalism will be 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, 1985). Secrecy is not an option under this norm. As Merton (1974) stated, scientific findings are products of collaboration and therefore the findings should belong to the community. This could apply to any scientific finding from Salk's polio vaccine to the production of recombinant DNA. Within the framework of the norm of communalism, one could argue that both discoveries should have been freely available to the community at large which the former was and the latter was not. Furthermore, a scientist who is a communalism purist likely experiences confusion or dissonance when engaged in research discoveries funded by private industry. For example, contract agreements might be required of the researcher in which they are required to delay publishing findings in academic journals (Mowery, 2005). It could even be possible that the researcher would be barred from publishing any of the findings.

Universalism.

The norm of universalism within science reflects 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 is 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 their 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, she 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.

Disinterestedness is defined as “the preference for the advancement of knowledge as opposed to the individual motives of the scientist” (Braxton, 1985, p. 312). In adhering to this norm, for example, 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, according to the norm of disinterestedness, should be solely focused on what the findings will add to the body of knowledge and not on any personal reward, monetary or otherwise. Macfarlane and Cheng (2008) addressed this norm directly by asking in their survey if researchers aligned their research with funding opportunities. The flipside 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 seeking 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. Based on the scientific method and the norms of scholarly conduct, *truth* should be expected as espoused by the German research model that undergirded the rise of the research university in the United States (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 (Merton, 1973). The process by which research is presented and then others attempt to replicate or refute the work is the archetypical example of organized skepticism.

Counter Norms of Science

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 (1974) 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 (1949) 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, and Barber, as cited in Mitroff, 1974). Mitroff (1974) 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 have been defined.

Solitariness.

As 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 can be seen in the polio vaccine example, Jonas Salk exhibited behavior consistent with the norm of communalism while Cohen and Boyer with Recombinant DNA 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 own or be monetarily benefited by, a patent and any licensing revenue generated. With the advent of the Bayh Dole Act and an environment where financial incentives are seen not as anathema to but facilitator of big science, faculty inventors increasingly assert their right to own or receive favorable terms on the royalties from their inventions. The driving force behind this is best exhibited in the Inventor's Bill of Rights (Collins, 2010) unveiled at the Association of University Technology Manager'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 embodied 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) refer to as the Matthew Effect. The Matthew Effect hypothesizes that scientists who have made their mark in the professional academic world will tend to receive a disproportionate amount of credit than their lesser known peers who are making equal or greater contributions to the body of knowledge. While 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, interestedness, as might be inferred, refers to a situation where a scholar does have a motivation that is sourced in extrinsic benefit and not simply the intrinsic reward of the scholarship itself. Considerations of personal satisfaction and reputation that will be enhanced become considerations, as might financial benefit (Mitroff, 1974). In understanding interestedness, it is helpful to imagine a hypothetical situation whereby a scientist builds his or her research agenda based upon the successful receipt of NSF, NIH, or major private foundation grants. The researcher working from an interestedness norm perspective would be motivated by the returns to reputation and perhaps salary augments as a driver of choices in research agenda. The flipside 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 and with the funding component only a means to that end. Arriving at a specific conclusion is of no interest; it is getting to the underlying truth that matters most.

Organized dogmatism.

While organized skepticism characterizes a scientist as always seeking alternative explanations for others and of one’s own research findings, organized dogmatism describes a scientist who would be skeptical of other’s findings but not of his or her own. He or she would routinely aim to find fault or shortcomings with the research of others or of those on whom they scaffold their own research. In this latter situation, it is done as a means of explanation for their own failure to find a solid explanation for findings or to deflect the criticism they may receive from others (Mitroff, 1974). In further understanding the norm of organized dogmatism it is necessary to look briefly at Mitroff's (1974) findings. Mitroff's interviews for his Apollo study are additionally helpful for understanding organized dogmatism. As 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 you 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 Apollo study 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).

Operationalizing the Norms of Science

A body of scholarship has grown around the role of the norms of science and university faculty (Braxton, 1986; Braxton, 1990, 1993, 1999; Braxton & Baird, 2001) as well as applied to academic entrepreneurship and research commercialization (M. Anderson, 2000; M. S. Anderson, et al., 2007; M. S. Anderson, Ronning, De Vries, & Martinson, 2010; Macfarlane & Cheng, 2008). Recently Mertonian norms have also been investigated as they relate to academic administrators (Bray, 2010). The following discussion describes the findings of this body of scholarship as it relates to developing a survey instrument to measure faculty adherence to the norms of science.

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* conducted by Ladd and Lipset (1978).

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: 4 dependent variables, 8 independent variables, and 2 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, 3 to communalism, 1 to disinterestedness, and 5 to organized skepticism. Braxton tested two hypotheses using multiple regression analysis. His first hypothesis was to see if academics perceiving their colleagues as less adherent to the norms of science evidenced a greater likelihood of their 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 (1990) 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 (1990) 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, he argued, might explain 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) operationalized the dependent variable as 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 as in his previous study.

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 subscribe 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. Each survey respondent was 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 a 2 if the respondent claimed “to a great extent”, a 1 if the respondent claimed “to some extent”, and 0 if the respondent claimed “very little or not at all” (p. 448). Scores on the Mertonian norm scale represented “subscription to the norms” (p. 451) and scores on the Mitroff counter-norms represented “subscription to counternorms” (p. 451). The four item scores for subscription to norms and subscription to counternorms were summed a range of scores 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 evidenced their potential for developing an instrument that employs 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 National Institute of Health 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 her study, Anderson also included the norms of governance and quality along with their respective counter-norms of administration and quantity. In designing the survey, Anderson used one item for each of the norms and counter-norms and asked respondents 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” (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 that they perceived their academic counterparts as behaving in ways more consistent with Mitroff counter-norm behavior than Metonian normative behavior.

Bray (2010) used the norms of science in a study of academic deans. A 123-item survey was developed based on 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 (2010) utilized both exploratory and confirmatory factor analysis to investigate 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 actually grouped onto the four Mertonian norms of science. In performing his confirmatory factor analysis, Bray produced 13 factors. Bray's (2010) 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).

Methodology

The development of a norms of science instrument in this study followed a two phase, nine step process beginning with construct definition and ending with instrument optimization (DeVellis, 2003). Phase 1, instrument development, involved the following steps: Define constructs, generate items, define the scale measurement, select background data, composite the instrument, and finally gather expert review. Phase 2, instrument testing, involved the administration of the instrument, evaluation of the items, and finally instrument optimization.

In defining the constructs, the norms of science literature's of Merton (1973) and Mitroff (1974) were utilized to develop archetypes for each of the four norms and their respective counter norms. Generating actual items involved the more laborious process of modeling survey items after items found in the extent literature (Andersen, 2001; M. Anderson, 2000; M. S. Anderson, et al., 2007; M. S. Anderson, et al., 2010; Braxton, 1990; Macfarlane & Cheng, 2008) and author generated items based on the definitions provided by Merton (1973) and Mitroff (1974). Items were a mix of positively and negatively worded statements utilizing a forced choice Likert scale, six-point measure ranging from strongly agree to strongly disagree. Background questions asking for gender, discipline, years since receiving highest degree, number of publications, and number of patents in which the participant is a listed inventor were included at the end of the survey instrument. A panel of five experts in the field was then asked to review the instrument for face and content validity. Out of the initial 30-items generated for the instrument, some were removed and others reworded or combined with other items. The final instrument included 25 items and excluded any normative definitions so as not to lead respondents.

Phase 2 and the administration of the survey followed Dillman's (2007) tailored design method. The convenience sample was selected through mining departmental websites of five Midwestern research universities. Faculty from the disciplines of engineering, medicine, chemistry, and physics were represented. A Qaultrics' administered electronic survey was sent to 1,105 participants at the research universities. An initial e-mail message was sent in the spring of 2011 that explained the intent of the study and that participants would receive the survey link in the next few days. The survey link was then sent a few days later along with two follow-up e-mails to non-responders at one week intervals. As an incentive to participate, the participants were given the chance to have their e-mail address put into a drawing to receive a 16BG WiFi enabled iPad 2. Data collection was completed after three weeks.

Results

Participants

A total of 290 participants at least started the survey for a response rate of 26%. Two-hundred eighty participants completed the 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 criteria. Of the respondents, 72% were male and 28% were female with 30% of the respondents who reported being an inventor on at least one patent application and 44% having been the primary investigator on one or more industry sponsored projects. The academic disciplines were represented as follows: Engineering 18%; Physics 1%; Chemistry 23%; Medicine 26%; other 31%. Academic ranks were represented as follows: Assistant professor 30%; Associate professor 29%; Professor 37%; instructor or lecturer 2%; adjunct faculty 0.4%; and other 1%. Descriptive statistics of the participants are shown in Table 1.

Factor Analysis

An exploratory factor analysis utilizing principal components extraction with a Varimax rotation was performed using SPSS. Prior to running the analysis, however, additional tests of the data for the suitability of factor analysis were performed. These two tests included the Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett’s Test of Sphericity. The finding for the former was .71 and for the latter, 1578.30 and significant, both affirming their adequacy and appropriateness for factor analysis (Tabachnick & Fidell, 2000).

From there, the factor analysis was run using the rubrics of having Eigenvalues greater than 1.0 and a visual inspection of the scree plot where it elbowed as the initial tools for determining the number of factors. Table 1 presents the Eigen values and Figure 1 the scree plot for the data.

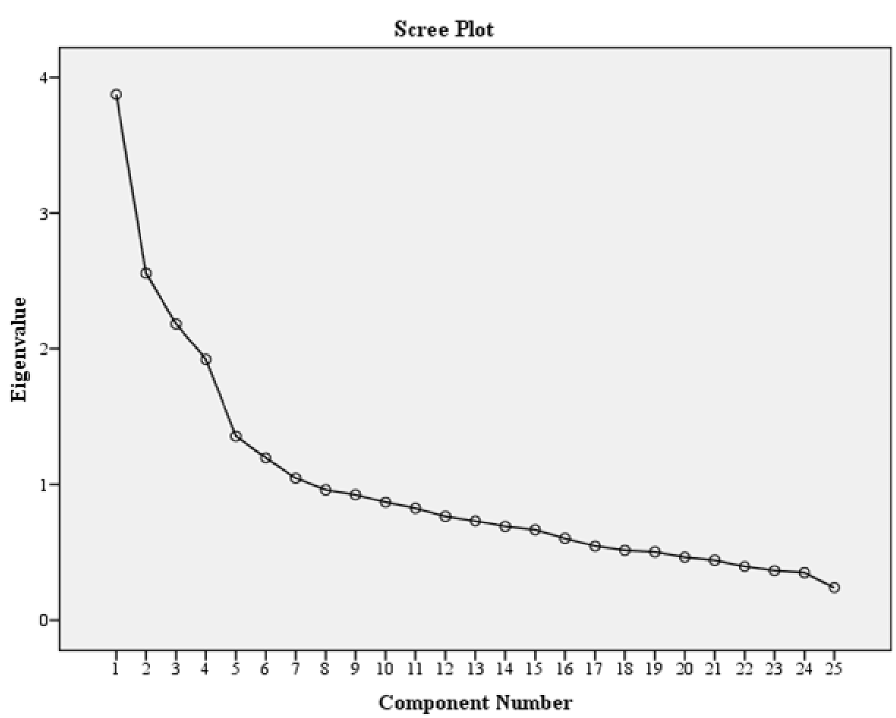
Table 1.

Eigenvalue Scores above 1.0 for Principal Components Extraction of the Norms of Science Instrument, % of Variance, and Cumulative %.

	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

Figure 1.

Scree Plot showing a leveling off at the fifth factor.



As can be seen in the data, 4, 5, and 6 factor solutions seemed initially plausible and thus three rotated component matrices were subsequently run and inspected. The 5-factor solution (Table 2 below) was ultimately chosen as the optimal one given that the items loaded the best and with minimal cross-loadings.

Table 2

Five Factor Solution to Principal Components Extraction with Varimax Rotation

	Component				
Items	1	2	3	4	5
A researcher should be as skeptical of one's own findings as he/she is of others.	**.783**	.130	.067	.0	-.019
A researcher should seek evidence that contradicts his/her hypothesis.	**.762**	-.047	-.110	.084	-.069
Researchers ought to be skeptical of the findings of other researchers.	**.706**	.037	-.005	.013	-.113
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.	**.646**	.146	.035	.145	-.071
It is important for a faculty member to highlight study limitations in any research he/she seeks to present or publish.	**.597**	.078	.134	.273	.051
Generally, when peer reviewing for a publication within your field, it is important to know the lead author's country of origin.*	.067	**.663**	.026	.044	-.073
The evaluation of a piece of research should consider the gender of the researcher.*	.122	**.631**	.031	-.068	.074
The institution that conferred a researcher's highest degree should be taken into consideration when evaluation scholarly contributions submitted to a peer reviewed journal.*	.258	**.618**	-.005	-.132	.245
When reviewing a conference paper or journal manuscript it would be helpful if the reviewers knew something about the author.*	-.137	**.616**	.064	.237	.224
The evaluation of a piece of research should be based upon the quality of the work and not the track record of the researcher.	-.020	**.529**	-.236	.250	-.146
The possibility of public and media acclaim for one's research is an important consideration when starting a research project or direction of inquiry.	.064	**.473**	.248	.156	.131
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.*	.100	**.463**	.201	-.133	-.287
Non-disclosure agreements are a reasonable tool for protecting research findings from being used by others for potential financial gain.*	.152	.017	**.785**	-.026	-.007
It is appropriate to delay the submission of a piece of industry sponsored research for publication consideration so the firm can assess business implications.*	-.069	.121	**.687**	.224	.004

The integration of confidentiality/non-disclosure language in contractual agreements between academic researchers for the sharing of research material, data, or findings is appropriate.*	.145	-.054	**.661**	-.172	.016
It is appropriate to delay the publication of findings for 60 days while the findings are evaluated for possible patent protections.*	-.254	.127	**.653**	.070	-.129
Opportunities for funding ought to drive choices for a research project or stream.*	.121	.051	**.33**	**.33**	.244
Science would benefit if more researchers chose to pursue projects based solely on the discovery of new knowledge free from considerations of personal benefit.	.128	.033	.093	**.711**	.148
Passion for discovery and not personal gain ought to be the driving force behind scientific endeavor.	.207	.079	.040	**.695**	-.092
In general, the only rewards researchers should expect to receive as a result of their findings are recognition and esteem.	.112	-.093	.039	**.690**	-.160
Blind review is the only appropriate way to ensure that the best research is published.	-.049	.098	-.113	**.448**	.114
Researchers should openly share findings with colleagues.	.073	.132	.229	.211	**-.621**
A researcher's grants and scholarship record is as important a consideration when evaluating a grant proposal as the merit of the research proposed.*	-.091	.183	.145	.134	**.525**
During the peer review process, a reviewer should be aware of the lead author's past publications.*	-.108	**.33**	.106	.171	**.50**
Research outcomes are not something that anyone "owns" but rather should be made freely available upon request.	-.003	.165	.301	**.46**	**-.48**

Notes:
*Items with an * are reverse coded.*

All 5-items tested for capturing different aspects of *Organized Skepticism* loaded where expected (component scores ranging from .783 to .597) with little evidence of cross-loading. Five of the seven items crafted for *Universalism* loaded where expected (component scores ranging from .529 to .066). Two other items had suggestive evidence for being included in that factor. However, since the components were both below .5, they were dropped from inclusion in that factor. Four of the six items crafted for Communalism loaded highly on the third factor (component scores ranging from .785 to .653) while two did not. A total of five items loaded strongly onto a third factor, and given the nature of those items, this component has been named *Commercialism*. The notion of commercialism seemed appropriate because the items referred to concepts of financial gain, funding, secrecy, and the assessment of business implications especially as it relates to releasing findings and patent activity. Three of the six items crafted to capture *Disinterestness* loaded highly onto a fourth factor. A fourth item written to capture the universalism factor showed some evidence that it could also be considered part of the fourth factor. The nature of the four items suggested a different label for this factor, *Scientific Puritanism*. The notion of scientific puritanism is meant to construe an adherence to the virtue of science for the sake of pure discovery and attainment of knowledge without regard to who produces the knowledge or for what reward. A fifth factor had 4 items that loaded highly on it (component scores ranging from .621 to .501.). Although the 4th item did load nearly at the .5 cutoff, this item clearly cross-loaded and hence was dropped. Based on the nature of the items, 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 researchers. Table 3 below presents these five factors and their respective items.

Reliability Analysis

As presented and discussed above, factor analysis suggested that 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.

Organized Skepticism.

The five-item *Organized Skepticism* scale, with an alpha of .77, 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.

Universalism.

The *Universalism* scale of five items had a Cronbach's alpha score of .63, below the preferred .70 level, but while .70 is preferred, some studies do report alphas under .70 as legitimate (Tabachnick & Fidell, 2000). Hence, it appears that this scale is also valid and reliable and that the items appropriately capture 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.

Commercialism.

The *Commercialism* scale of four items resulted in a Cronbach's alpha of .66, still within an acceptable range. Thus, it appears that this scale is both valid and reliable and does capture aspects of practice associated with commercialization. These norm elements include issues of non-disclosure and confidentiality agreements on research findings as well as publication delays in order to explore potential for patenting.

Scientific Puritanism.

The *Scientific Puritanism* scale of 4 items had an alpha of .64, once more an acceptable internal reliability score. This finding suggests that the scale is internally reliable and as noted before, is also valid. Hence, the three items are suitable for capturing this particular norm of research element.

Communal-Meritocracy.

The three items that loaded highly on a 5^{th} factor and labeled *Communal-Meritocracy*, had a Cronbach's alpha of .242, a reliability statistic that is below an acceptable value. Three combinations of each item paired together were tested for reliability. None of the three combinations yielded an alpha above .30, therefore this factor was dropped from the final model. This factor was ultimately dropped from the set.

Table 3 shows the final 4 factors and their items as determined by the principal components extraction, varimax rotation, and reliability tests for each factor.

Table 3.

The Five 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.
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.	Opportunities for funding ought to drive choices for a research project or stream.*	

Discussion

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, we were able to find 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 (H 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 (Viale, 2010a, 2010b). Viale argues 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 (Viale, 2010a, 2010b) expands on Merton's social norms of science and includes 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 respectively: 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 we have called the Commercialism scale. Viale (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 (Viale, 2010a, 2010b) described this operational norm as a difference in ontology of the output of the research. While 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'.

Opportunities for Future Research

To summarize, this study has produced a valid and reliable instrument that includes scales which measure the Mertonian norms of science of Organized Skepticism and Universalism. Elements of the Commercialism and Scientific Puritanism scales share commonalities with Viale's (2010) operational norms of funding and results. While the next step in putting these scales into practice includes refining the instrument, administering another survey, and utilizing confirmatory factor analysis to verify construct validity, it also includes adding more background data into the survey to test for predictive validity. One might expect, for example, a more entrepreneurial academic scientist to more strongly agree with the items related to the Commercialism scale. It would be informative to request further self-reported data related to patent and spin off company creation at the individual unit of analysis while using data from the Association of University Technology Managers (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 (Viale, 2010a, 2010b) thesis introduced a stream of research that investigates 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, date, 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

While this study has 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, the alphas of the instrument and its subscales were not all greater than the typically accepted .70. In the case of the Communal-Meritocracy scale the alpha was lower than is acceptable and dropped from the set.

Second, this study used a convenience sample from the Midwest of the United States of America. 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 research universities. In other words, the results of the study could be geographically bounded.

Finally, norms can be a subjective component of organization phenomenon 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. In conclusion, the study succeeded in producing an instrument that measures adherence to the scientific norms of *Organized Skepticism, Universalism, Commercialism,* and *Scientific Puritanism*. While 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 both valid and reliable.

References

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. [10.1007/s11948-000-0002-6]. *Science and Engineering Ethics, 6*, 443-461.

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: 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. [Article]. *Journal of Higher Education, 81*, 366-393.

Blumenstyk, G. (2010, 2010/03/12/). Forum highlights Ways to tune up universities as engines of economic development. *Chronicle of Higher Education,* p. A22. Retrieved from http://ezproxy.indstate.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=f5h&AN=48758458&site=ehost-live

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: 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. [10.1007/BF00992162]. *Research in Higher Education, 34*(2), 213-228.

Braxton, J. M. (Ed.). (1999). *Perspectives on scholarly misconduct in the sciences*. Columbus: 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? [Article]. *Journal of Higher Education, 81*(3), 284.

Collins, B. (2010). INVENTOR'S BILL OF RIGHTS. [Article]. *Inventors' Digest, 26*(6), 34.

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

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), page #'s?.

DeVellis, R. F. (2003). *Scale development : theory and applications*. Thousand Oaks, Calif. ; London: SAGE.

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

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

Etzkowitz, H., & Viale, R. (2010). Polyvalent knowledge and the entrepreneurial university: A third academic revolution? *Critical Sociology, 36*(4), 595. Just one page?

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. [doi: DOI: 10.1016/S0048-7333(99)00069-4]. *Research Policy, 29*(2), 313-330.

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.

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

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

Merton, R. K., & Sztompka, P. (1996). *On social structure and science*. Chicago: 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*(4), 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: Elsevier.

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. [u.a.]: Univ. of Georgia Press.

Sztompka, P. (2007). Trust in Science: Robert K. Merton's Inspirations. *Journal of Classical Sociology*, *7*(2), 211-220. doi: 10.1177/1468795x07078038

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

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): Springer Berlin / Heidelberg.

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

Appendix

Below are the 6 point Liker scale items in the Norms of Science instrument along with the instructions that were provided to the participants.

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

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 180 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.

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

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 be based upon the quality of the work and not 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).

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

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

Please take a moment to reflect on organized skepticism and then note your level of agreement with the following statements.

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 they seek to present or publish.