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Reward Systems and NSF University Research Centers: The Impact of Tenure on University Scientists' Valuation of Applied and Commercially Relevant Research

Over the past three decades, U.S. science policy[1] has shifted from decentralized support of small, investigator-initiated research projects to more centralized, block grant-based, multidisciplinary research centers. No matter one's take on the "revolutionary" nature of this shift,[2] a major consequence is that university scientists, now more than ever, are subject to multiple and often conflicting demands. The purpose of this article is to examine the impact of having tenure on university scientists' consideration of these demands, particularly the demand for applied and commercially relevant research.

We are interested in scientists who work in a particular type of university research center, one previously referred to as the "multidiscipline multipurpose university research center," or MMURC (Bozeman & Boardman, 2003, 2004b). These scientists are interesting because MMURCs, at least those funded by the federal government (e.g., the National Science Foundation's Engineering Research Centers and Science and Technology Centers programs), require that scientists be tenured or occupy a tenure-track position in an academic department.

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More important here, MMURCs expect of university scientists research and other behaviors that generally do not align with the traditional university reward system. As a faculty member in the traditional academic department, the contemporary university scientist has a key responsibility to create knowledge, and for the most part success is measured by peer evaluation and publication despite calls for emphasis in tenure and promotion decisions on the many other activities and tasks (e.g., teaching, applied research, and community outreach) that university scientists perform (Boyer, 1990; Braxton & Del Favero, 2002; Diamond, 1993, 1999). As MMURC faculty, the university scientist generally works as part of a multidisciplinary and interinstitutional effort to apply existing knowledge, and success in many cases is measured in terms of technology transfer from university to industry.[3] In fact, this issue of misalignment between reward systems and faculty behavior is a problem not just for university faculty in the hard sciences or more specifically in MMURCs, but also for faculty working in the social sciences and in professional fields including medicine, business, and management.[4]

Geisler (1989) has suggested that such misalignment may discourage university scientists who are not tenured but who are tenure-track (hereafter referred to as "junior-level scientists") from performing applied science with industrial partners:

> Faculties in research universities are required to conduct basic research and to publish the results. Such research outputs are then used in promotion and compensation decisions. Therefore, when working on industrial type problems, faculty may feel constrained by limitations of time and by the publishability of the research they undertake. This is particularly the case with junior faculty, reluctant to join an industry-sponsored project that demands time but may not hold much promise of academic outputs and rewards. (p. 50)

Further, university administrators often incorrectly assume that extradepartmental research units such as MMURCs have no problems in getting untenured university scientists to engage in applied research and related technology transfer activities (Friedman & Friedman, 1985).

More recently, the Association for the Study of Higher Education (ASHE) expressed this sentiment in its Higher Education Report, reporting that the traditional university reward system pays short shrift to applied and industry-related research, thereby hindering the "institutionalization of the scholarship of application" (Braxton, Luckey, & Helland, 2002, pp. 74–75). Similarly, a recent presentation by Lynn Preston,[5] Director of the Engineering Research Centers (ERC) Program at the National Science Foundation (NSF), to the American Society of Engineering Education (ASEE) Engineering Research Council highlighted that tenure and promotion committees are more often than not too narrowly defined. Preston also pointed out that MMURC-based publications are often not recognized by tenure committees and, if they are recognized, are "discounted" in value in tenure and promotion decisions. As with Geisler (1989), both the ASHE and ASEE reports concluded that the traditional university reward system may be deterring junior-level faculty from performing MMURC research, research that is applied and commercially relevant.[6]

So why then do junior-level scientists choose to affiliate with MMURCs? Drawing from interviews with both tenured and junior-level scientists working at NSF ERCs and Science and Technology Centers (STCs), Bozeman and Boardman (2004a) found that incentives for junior-level scientists include "doing good" for society, gaining access to resources (e.g., research funds, equipment and labs, graduate students), and associating oneself with the prestige that MMURCs may carry in a particular research field. Junior-level scientists also seek MMURC resources to aid them in their publishing endeavors but admit that they sometimes shun MMURC duties that do not help them to publish, such as interacting with industrial partners (Bozeman & Boardman, 2004a).

There is little to no empirical assessment of the assertion that the traditional university reward system deters junior-level scientists from conducting applied and commercially relevant science (Dooris & Fairweather, 1992; Friedman & Friedman, 1985). After a brief review of the literatures on contemporary scientific values and the traditional university reward system, we model and test the impact of having tenure on MMURC scientists' reported scientific values as they pertain to applied and commercially relevant research. Before this, however, we feel it necessary to recognize two criticisms of our model in the context that we have laid out thus far. First, often reported values and actual behaviors may diverge, perhaps even significantly. Second, nothing in our model necessitates that any divergence in reported preferences between tenured and junior-level scientists is strictly owing to any particular characteristic of or bias inherent to the traditional university reward system. However, because tenure is perhaps the most broadly coveted prize that the traditional university reward system has to offer, looking at the impact that being tenured has on research preferences naturally leads one to consider the characteristics of the institutional system and attendant arrangements that grant or deny university scientists tenured status.

We therefore contend that this study constitutes an important incremental step towards demonstrating (a) that the "second academic revolution" (Etzkowitz, 2001; Etzkowitz & Leydesdorff, 2000) is incomplete in that it has not yet won the hearts and minds of all (e.g., junior-level) university scientists, and (b) that the current university reward system in the U.S. may indeed be deterring junior-level scientists from performing the applied and commercially relevant research that “Research I” universities encourage and tout in their research mission statements (Keohane, 1993). However, because of the current state of empirical research on this important topic, which is anecdotal or “very limited” at best, we stop short of other studies and reports in that we do not advocate the ad hoc sorts of recommendations for amending the university reward system being discussed in higher education and science policy circles, as there is not yet a full understanding of what the ramifications of such changes will be.

Instead, we promote our study in two ways. Most important, due to the heretofore unseen generalizability of this study’s results, it helps to solidify the evidentiary foundation of calls for a reassessment and perhaps some measure of reform of the university reward system. Further, the results clearly justify additional qualitative and quantitative research assessing, respectively, (a) the “causal mechanism” (Lin, 1998) of receiving tenure and its impact over time on university scientists’ values and behaviors, and (b) the correlations between variables regarding not only the values and research preferences of university scientists, which we consider here, but also the relationships between values and preferences and variables isolating the behaviors and discrete outputs of university scientists. We feel this type of research to be vital for developing practicable and effective amendments to the university reward system.

Literature Review

This literature review is divided into three sections. Due to the nature of the data we employ, the first section focuses on contemporary scientific values and how these values have been fundamentally transformed by closer and more frequent university-industry interaction, the key papers in this line of scholarship being Henry Etzkowitz’s empirical case studies of “entrepreneurial” university scientists (1998) and universities (2000). The second section reviews studies claiming an incongruity between the type of science that research universities advocate and the type of science that academic departments reward. Studies in this section we draw from the research policy, social studies of science, and higher education literatures. Though this line of scholarship certainly includes systematic empirical study, much of it is geared toward the vital task of problem identification (in terms of setting policy agenda, see for example Kingdon, 1984; True, Baumgartner, & Jones, 1999). Appropriate to this early phase in the process of policy change, it employs mostly anecdotal evidence in this task. The third section contains those few papers that, like ours, situate themselves at the intersection of sections 1 and 2, assessing the impact that academic rewards have on scientific, and more generally academic, values.

Contemporary Scientific Values

In his empirical case studies of the emergence of a "commercial ethos" in contemporary university science, Henry Etzkowitz addressed two units of analysis—university scientists and the institutions to which those scientists are beholden. He analyzed the first unit, the scientists, in his study of the cognitive effects of university-industry collaboration (1998). In this study, Etzkowitz cited a value shift wherein the traditional scientific value "extension of knowledge" is incorporated into a compatible relationship with the entrepreneurial scientific value "capitalization of knowledge" (p. 824). He claimed this melding of ideals to be historically revolutionary in that, traditionally, academe has considered the two antithetical. Etzkowitz was careful not to overextend his logic to the institutions in which these scientists conduct their research, acknowledging that the "model of separate spheres and technology transfer across strongly defined boundaries is still commonplace" (p. 827). In a later paper, rather than look at individual scientists, Etzkowitz (2000) analyzed the "entrepreneurial university" wherein the commercialization of intellectual property rights constitutes a formal institutional objective. Again, he retained his cautious tone by noting a persistent, institutional-level tension between Mertonian "disinterestedness" (Merton & Storer, 1973) and entrepreneurial values.

We advocate similar caution when making claims about individual scientists' values vis-à-vis the contemporary university ethos discussed by Etzkowitz. Institutions are comprised of individuals, and as institutions change fundamentally, these changes necessarily affect the work life and attitudes of individuals. Accordingly, if these changes at the institutional level are partial or incomplete, so too should be any changes that occur at the individual level of analysis. All else being equal, we feel that the cognitive effects of closer interaction between university and industry that Etzkowitz has studied do not apply, at least not in full, to junior-level scientists who may indeed favor the "extension of knowledge" and at least partially resist the "capitalization of knowledge" until after they receive tenure.

University Research Missions and Reward Systems

Studies in the higher education literature have identified an incongruity between the traditional university reward system and the "commercial ethos" that modern research universities encourage. Boyer (1990) observed that the traditional university reward system, which rewards articles in refereed academic journals, book chapters, and academic monographs, does not match up well with the daily tasks performed by university scientists, such as teaching and applied work. Nor does it match well with the research missions of most colleges and universities, which in addition to the creation of knowledge emphasize teaching, technology transfer, and economic development. Picking up where Boyer left off, Diamond (1993, 1999) and Braxton and Del Favero (2002) questioned the appropriateness of traditional assessment methods, calling for a higher degree of correspondence between tenure and promotion systems and the activities encouraged by university missions. Similarly, though much more systematic in their approach, Arreola, Theall, and Aleamoni (2003) constructed a "metaprofession model" to help better conceptualize and distinguish the many roles that university faculty perform, arguing that such a model (or a comparable model or heuristic) demonstrates that tasks important to the professional development of university faculty are not exclusively scholarly or extensions of scholarship, pointing to the need for broader scope in tenure and promotion decisions.

Many research policy and social studies of science scholars have implied that responding to this call is no light task. Brooks (1978) argued that traditional academic peer review is suitable for defined fields but not for interdisciplinary fields, and for assessing new knowledge for its own sake but not for measuring the usefulness or applicability of that knowledge. Porter and Rossini (1985) demonstrated that NSF reviewers favor research proposals that are familiar to them and that are related to their respective fields of expertise, citing discrimination against interdisciplinary research. More recently, Bozeman (1993) pointed out that peer review is ill suited for assessing commercially relevant work, while Siegel, Waldman, Atwater, and Link (2003) suggested that there may be bias in tenure and promotion decisions favoring single-discipline and basic research over applied and commercially relevant projects.

In contrast, Morris (2002) showed that many academic departments are adapting to the emergent culture of the MMURC by becoming more problem-driven and applied. However, in this article we make the cautious assumption that we advocate above with respect to assessing contemporary scientific values. MMURCs are relatively recent phenomena, quite young when compared to the academic department, and there is much evidence in the literature that the traditional university reward system is intact and does not necessarily reward applied and commercially relevant research (Arreola et al., 2003; Bozeman & Boardman, 2003, 2004a).

The Impact of Rewards on Values

We have identified only two studies that assess the impact of having tenure (among other attributes) on the values of university scientists (i.e., Dooris & Fairweather, 1992; Nora & Olivas, 1988). The study by Nora and Olivas (1992) is somewhat peripheral but not unrelated in assessing how, via editorships and board memberships, senior or "privileged" faculty members control the range of normative behaviors deemed "acceptable" in a given academic field or discipline. More similar to the current study, the research conducted by Dooris and Fairweather (1992) demonstrated that, for university scientists working in biotechnology, tenured status is positively correlated with the percentage of research funds procured from industry. The authors also demonstrated that the effect of having tenure on this percentage is stronger than the effect of "organizational structure," of belonging to an extradepartmental research unit geared towards technology transfer, such as an MMURC. Although our study differs in obvious ways, with its emphasis on scientific values and theoretical focus on the emergence of a "commercial ethos" in academic science (Etzkowitz, 1998; Etzkowitz & Leydesdorff, 2000), it is similar in its implication that the ineffectiveness of institutional approaches to altering scientific attitudes and behaviors in American universities substantiates rethinking the extant academic reward structure.

Hypotheses and Model

In this study we tested the general hypothesis that junior-level scientists will, relative to their tenured counterparts, devalue applied and commercially relevant research in favor of basic research, which we feel is justified by (a) some basic microeconomic reasoning and (b) implications of the above-discussed literature.

Participation in MMURC research is often viewed by junior-level scientists as time and effort taken away from potentially academic career-advancing activities (Bozeman & Boardman, 2004a). Junior-level scientists working in MMURCs therefore incur a higher cost (the "cost" of working in an MMURC in addition to an academic department versus working only in an academic department), at least in terms of academic career advancement, than do tenured faculty working in these centers. Following this logic, we expected junior-level scientists' responses (see below) to be more "agreeable," assuming that their academic departments employ the traditional assessment template for tenure and promotion decisions, rewarding articles in refereed academic journals, book chapters, and academic monographs over applied research resulting in technology transfer of one form or another.

Much of the above-discussed literature speculatively suggests not only that our hypotheses are plausible (Bozeman & Boardman, 2003, 2004a; Geisler, 1989; Siegel et al., 2003), but also (with no empirical support beyond anecdotes) that they would be in fact already proved true (Braxton & Del Favero, 2002; Diamond, 1993, 1999). Any serious calls for reform of the traditional university reward system's emphasis on scholarly publication at the expense of activities related to teaching, service, and technology transfer (see Boyer, 1990; Braxton et al., 2002) requires empirical support for its basic premise that junior-level scientists behave differently than do their tenured counterparts due to the nature of the university reward system. While we recognize that reported values and actual behaviors may diverge somewhat, our model and attendant hypotheses nonetheless will provide results serving as key evidence informing discussion and debate over whether the university reward system deters junior-level scientists from performing applied and commercially relevant research.

To test our hypothesis, we employed the following model for two dependent variables constituted respectively by two survey items (discussed below) that ask about the respondent's preference for or aversion to applied and commercially relevant research:

$$y = \beta_0 + \beta_1 tenure + \beta_2 age + \beta_3 male + \beta_4 discipline + \beta_5 collaboration + \beta_6 work\ in\ industry$$

The explanatory variable, tenure, is a binary variable coded 1 if the respondent is tenured, 0 if the respondent is untenured but tenure-track. We controlled for age group,[7] gender, scientific discipline, whether the respondent has worked in industry jobs prior to his or her current academic position (industry experience being presumably influential in one's perceptions of research), and the propensity to collaborate. Propensity to collaborate is a necessary control, as some researchers may prefer independent work versus collaborative work, which in itself may influence the likelihood of engaging in applied work that is often interdisciplinary and therefore collaborative.

The survey items that constitute our two dependent variables were designed to elicit Likert-type responses[8] pertaining to respondents' valuation of basic, applied, commercial, and socially oriented research:

1. Worrying about possible commercial applications distracts one from doing good research. This statement was designed to elicit from respondents a valuation of the scientific merit of post–basic research "application" activities. The item was placed within the section of our survey entitled "Scientific values," which asks about a variety of research preferences.[9] We hypothesized a negative relationship between this item and our chief explanatory variable, tenure. Junior-level scientists are more likely to believe that worrying about commercial application detracts from the quality of basic research, ceteris paribus.

2. I am more interested in developing fundamental knowledge than in the near-term economic or social applications of science and technology. Similarly, this item was designed to elicit from respondents another valuation of post–basic research "application" activities, this time a relative ranking of personal interest in basic versus applied work rather than a comparison of merit. Some scientists may prefer to produce new knowledge and little else; others may be more concerned with the practical application of new knowledge. Again, we hypothesized a negative relationship between this item and our chief explanatory variable, tenure. Junior-level scientists are less likely than their tenured counterparts to be more interested in applied and commercially relevant research than basic research, ceteris paribus.

Data

The data for the current study come from the Research Value Mapping Program (RVM) at Georgia Tech's School of Public Policy. In 2002–2003, RVM mailed a questionnaire to 997 university faculty members participating in MMURCs, a systematic sample from another database that includes Curriculum Vitae data stratified across U.S. universities by field. After two mailings, executed in accordance with the tailored design method (Dillman, 2000), RVM received 451 questionnaires for a response rate of 45%. The questionnaire included questions about research collaboration, grants and contracts, job selection, work environment, and demographic information. Of particular importance to the current study are questions pertaining to scientists' attitudes toward various modes of scientific research, which we discuss at length below. The respondents include 63% tenured, 86% male, and 70% U.S.-born scientists. The gender ratio and U.S.-born/immigrant ratio in the sample approximate the national levels (Bozeman & Corley, 2004).

From the 451 respondents in the survey data set, 103 respondents (22.8%) are neither tenured nor on tenure-track positions (e.g., research faculty, postdoctoral fellows, research group leaders, managers) and are therefore theoretically irrelevant to the current study. After we excluded these respondents, the data set we used for our analysis contained 348 observations, including only tenure-track and tenured faculty.

Eighty percent of the respondents in the sample are tenured (N = 278), and the remaining 70 respondents are junior level scientist who are

TABLE 1
Descriptive statistics

	N	Mean	Std. Deviation
Tenured faculty	348	0.799	0.4014
Worrying about commercial applications distracts one from doing good research	346	2.139	0.840
I am more concerned in developing fundamental knowledge than in the near-term economic or social applications of science and technology	344	2.875	0.860
Gender	347	0.870	0.336
Age	334	49	9.72

employed in tenure-track positions. Thirteen percent of the respondents are females (N = 45) and 15% at some point had a job in industry prior to their current academic position. The majority of the respondents (69.4%) are almost equally distributed in the 30–39 and the 40–49 age groups; 7.2% of the respondents (N = 24) are in the age group 20–29, 18% (N = 60) in 50–59, and 5.2% (N = 18) in the age group 60–69.

Method and Findings

We employed two ordered logit regressions for each of the above-listed survey items as dependent variables, per the above-specified model.[10]

Both models produced statistically significant results at the 5% level regarding our chief explanatory variable, tenure. The direction of the estimator in both cases is negative, as we hypothesized. Model 1 demonstrated that tenured scientists working in MMURCs are less worried than are their junior-level counterparts about the consideration of commercial application during research detracting from the quality of that research. Model 2 demonstrated that tenured scientists working in MMURCs are more interested in the economic or social applications of their research than are junior-level scientists. We discuss these findings below.

In models with limited or categorical dependent variables, the marginal effects of the independent variables are not constant but are conditional on the values of all other independent variables. However, since the particular circumstances of the respondents beyond their tenure status were beyond our interest here, to estimate the marginal effects of

TABLE 2
Ordered logit regression results

	(1) a.	(2) b.
Tenured	–0.665**	–0.632**
	(0.303)	(0.303)
Gender	0.466	0.432
	(0.319)	(0.343)
Age group	0.057	0.106
	(0.129)	(0.127)
Biology and life sciences	0.294	1.288*
	(0.648)	(0.672)
Computer science	0.073	0.248
	(0.713)	(0.755)
Chemical engineering	0.074	0.146
	(0.671)	(0.692)
Civil engineering	0.372	–0.807
	(0.747)	(0.774)
Electrical engineering	0.121	0.501
	(0.659)	(0.673)
Mechanical engineering	0.258	0.150
	(0.699)	(0.717)
Other engineering sciences	0.682	–0.328
	(0.685)	(0.705)
Chemistry	–0.123	1.061
	(0.700)	(0.701)
Physics	–0.027	0.783
	(0.707)	(0.724)
Other natural sciences	0.570	0.676
	(0.646)	(0.665)
Proportion of collaborative papers	0.532	1.080
	(0.775)	(0.773)
Job in industry prior to current position	–0.261	–0.563*
	(0.332)	(0.326)
Observations	319	319

Standard errors in parentheses
a. Dependent variable: "Worrying about possible commercial applications distracts one from doing good research"
b. Dependent variable: "I am more interested in developing fundamental knowledge than in the near-term economic or social applications of science and technology."
*$p < 0.10$ **$p < 0.05$

having tenure we kept all other independent variables constant at their means. The resulting elasticities show that being tenured is associated with (a) an 11 percentage points decrease in the probability that a scientist is worried about commercial applications distracting from performing "good" research and (b) a 19 percentage points decrease in the probability of being more interested in developing fundamental knowledge than in the near-term economic or social applications of science and technology.

Additionally, the second model contained two statistically significant estimators, one a scientific discipline and the other indicating prior work in industry. For the biological and life sciences, the model indicated that, tenured or not, researchers in these fields are more interested in developing fundamental knowledge than in the commercial application of knowledge. A possible explanation for this result is that, even though the distinction between basic and applied science is blurred (Stokes, 1997), traditionally some sciences have been more "basic" and may indeed be perceived as such by the scientists practicing those disciplines. However, this rationale does not explain the statistical insignificance of the estimator for physicists, nor that for the estimators for the numerous disciplines in the engineering field.

For prior work in industry, the observed effect is plausible in that researchers who have worked in private companies are more likely to have been exposed to commercial work with near-term economic application. This prior exposure may in turn produce in scientists a predisposition toward the application of knowledge. It is important to note that prior industry experience does not affect the statistical significance or direction of our chief explanatory variable, tenure.

In the next section, we discuss the evidentiary status of these results regarding the debate over the academic reward system's emphasis on peer-reviewed publications. We consider what these results mean and what they do not in terms of our data, model specification, and sample selection. We also address some issues related to our method of analysis.

Discussion

Our findings support the general—and, until now, empirically untested—notions from science policy and higher education circles that junior-level scientists value basic over applied research and that they do not value commercially relevant research as highly as do their tenured colleagues. What our findings imply (but fail to prove) is that this divergence in reported preferences between tenured and junior-level scientists is strictly owing to any particular characteristic of or bias inherent to the traditional university reward system. There may exist, for example, heretofore unidentified differences between junior-level and tenured scientists that can better explain the divergence in scientific values that our results demonstrate, differences that are entirely unrelated to the traditional faculty assessment template employed currently by most U.S. research universities.

While our results do not constitute undeniable proof of a "deterrence effect," nonetheless they do provide a solid evidentiary basis for the existence of such an effect—more solid at least than that which existed before this study. This evidentiary basis is solid first in that our results do not contradict the case-based claims of earlier policy and scholarly considerations of the topic. Thus, our quantitative assessment in this article is reinforced by earlier anecdotal assessments, and vice versa. Second, in our models we control for the "stand-bys" that are included in most rigorous empirical assessments of scientific values, including age group (to control for cohort effects), scientific discipline (to control for the more "basic" or "applied" natures of various areas of study), and gender, as well as for previous industry experience. Therefore, the potential for spuriousness is minimized to the extent that the data allow. The third way in which our results provide solid backing for the charge that the university reward system deters junior-level scientists from conducting applied research is related to the impact that institutions inevitably have on individuals. Because tenure is perhaps the most coveted reward that the traditional research university has to offer its faculty, looking at the impact that being tenured has on scientific values naturally leads one to consider the characteristics of the institutional system, its attendant norms and values, and the metrics it assesses (DiMaggio, 1988) in decision processes whereby university scientists are granted or denied the status of tenure.

Also important to the evidentiary basis that our results constitute is the nature of our sample. At first, it seems reasonable to charge that we have a selection bias problem, given that every survey respondent is a scientist who works in an MMURC. Therefore we consider no control group of scientists leading traditional academic careers in departments alone. If the objective of this study was to juxtapose the scientific values of MMURC scientists versus those of more traditional, non-MMURC university scientists, we would categorically agree with this charge. But this is not our objective. The primary goal of this article is to test empirically whether being untenured detracts from the value scientists who are subjected to institutional norms and practices encouraging nontraditional, applied, and commercially relevant research place on said research. Hence, our results indicating that having tenure exerts the negative effects we hypothesized (see Table 2 above) necessarily allow for bolder inferences regarding the role that the academic reward system plays in the research preferences and activities of university scientists. Even those scientists with official license to conduct industry-related research devalue such research when they do not have tenure.

Before discussing the implications of our results for policy and research, we must be careful to avoid the overinterpretation that sometimes accompanies the use of econometric methods (Levy, 1968).

Specifically, we refrain from interpreting the impact of tenured status that our model demonstrates as signifying a "trigger effect" wherein, once a scientist receives tenure, he or she automatically rethinks (or subconsciously "refeels") his or her stance regarding basic versus applied and commercially relevant research. We propose but do not elaborate here that junior-level scientists emphasize what Etzkowitz (1998) calls the "extension of knowledge" and the attendant focus on publications at the expense of the "capitalization of knowledge" and the attendant focus on applied or commercial activities primarily because, being for the most part young scientists who are early in their scientific careers, they have little knowledge upon which to capitalize and therefore focus on creating and publishing new, albeit usually incrementally new,[11] knowledge.

Implications for Policy

Per our discussion above, the key policy implication this study constitutes is simple: By adding a generalizable set of results to the current mix of anecdotes and specific cases that argue that the traditional academic reward system is ill suited to provide university scientists incentive to perform research and other activities that diverge from the publication of peer-reviewed basic research, the evidentiary basis for the argument is thereby strengthened significantly, at least with respect to the research-related activities of university scientists. In turn, policy makers have a stronger footing from which to call for reform as well as for funding further research on the topic with public monies. However, we are compelled to review some deficiencies in existing calls for reform and to qualify the types of policy action we feel our research supports.

Most relevant of extant suggestions for bringing into closer alignment the university reward system and the activities of university scientists is directly related to MMURCs. ERC Program Director Lynn Preston emphasized in her report to the ASEE Engineering Research Council the importance of tenure and promotion committees attributing equal weight to cross-disciplinary and single-discipline work and ensuring that senior ERC faculty see that junior-level scientists publish their center research in journals that are valued by their academic departments as well as by their centers. However, while certainly this is an important issue regarding the perceived gap between university research missions and the university reward system, it overlooks our focus here on applied and commercially relevant research, which does not always result in publication but rather, ideally, in technology transfer of one form or another.

Scholars too have offered many policy prescriptions for broadening the scope of outcomes that count in tenure and promotion decisions. Braxton and Bayer (1986) employed the broadest prescription, counting any activity that requires disciplinary knowledge and skill. Others (Braxton et al., 2002; Diamond, 1993, 1999; Glassick, Huber, & Maeroff, 1997; Schulman & Hutchings, 1998) have been more specific, advocating criteria with which to categorize an activity, including but not limited to publishing in peer-reviewed journals or books, as "scholarly" or not. The criteria include the publicness, amenability to peer review, replicability, documentability, impact, and innovativeness of an activity—be it publishing, basic or applied research, teaching, collaborating with industry, developing prototypes, or mentoring graduate students, to name a few.

A quick review of this short list nevertheless reveals why the traditional university reward system has persisted, more or less unchanged, for so long. Some of the criteria are simply difficult to conceptualize due to vagueness (publicness, impact, innovativeness), while others are most easily conceptualized as a consequence of publishing. To illustrate the latter, it is hard to imagine how a scientist at the University of California could replicate an experiment conducted by a scientist at Georgia Tech without the Georgia Tech scientist first publishing her research methods and results in a journal read widely by scientists in her discipline or field. Similarly, publication renders scientific research more amenable to peer review, documentability, and impact. Only the criteria of innovativeness lends itself to the type of revision of the university reward system that our results imply are necessary for junior-level MMURC scientists to place a higher value on applied and commercially relevant research vis-à-vis basic research geared primarily towards publication.

Despite these difficulties, the results of this study strongly suggest that policy makers and scholars are correct in their collective assumption that the university reward system must be altered if we are to get university scientists to focus on the wide variety of tasks we as a society deem equally important as, if not more important than, the publication of basic research. However, with our findings we do not advocate ad hoc amendments to the university reward system. Rather, we emphasize caution until further research (discussed below) is conducted, because dramatically adjusting the manner with which we go about rewarding academic scholarship without adequately reviewing the potential impacts of those adjustments may result in the undermining of a reward system that has helped to ensure the rigor and reputation of U.S. scholarship for more than a century, not to mention that "appropriate" patterns of professional behavior have been shown to differ quite significantly across the disciplines (Fenker, 1975). In fact, there are still those who have asserted that no change is required at all (see Arreola et al., 2003). We therefore feel it imprudent for policy makers, in their calls for revision of that system, to assume that simply changing the rules will easily or automatically result in the cognitive transformation and "commercial ethos" that Etzkowitz discusses in his works on the second academic revolution (Etzkowitz, 1998; Etzkowitz & Leydesdorff, 2000).

Conclusion

In this article, we have strengthened the evidentiary foundation of arguments calling for reform of the academic reward system in its traditional form by demonstrating that the scientific values of junior-level scientists' working in MMURCs are not aligned with the applied and commercial research goals of MMURCs and of the universities in which these centers are embedded. We have also qualified that this foundation nonetheless remains somewhat shaky pending further empirical research. This additional research should assess data collected from a representative sample of U.S. university scientists that considers variables measuring not only the values and research preferences, as we consider here, but also variables isolating the actual behaviors and outputs of university scientists.

Variables tracking the behaviors of university scientists are somewhat rare in scholarly treatments aimed at inferences drawn from general results, but they may include, for instance, measures of the percentage of research time per week allotted to different types of industry interactions, including but not limited to joint research on applied and commercially relevant projects. Variables tracking the outputs of university scientists are much more common, including absolute and weighted counts of discrete outputs such as publications and patents as proxies for "basic" and "commercially relevant" research productivity, respectively. An important goal for future research, then, is to correlate university scientists' reported scientific values with actual behaviors and outputs to develop a clearer understanding of who in U.S. universities performs what type of research (as well as other activities including teaching, student mentoring, etc.) and why.

Let us be clear, however, that quantitative analysis of more comprehensive data sets and inferences drawn from general results are not all that future research requires. New research also must include more systematic and rigorous case treatments of university scientists' behaviors, especially regarding the "causal mechanism" (Lin, 1998) of acquiring the status of tenure. This research ideally would include longitudinal case data tracking the interplay between institutional contexts and the values and behaviors of university scientists as they progress in their academic careers from assistant to associate professor, and then in fewer cases from associate professor to full professor. This type of research is requisite for avoiding oversimplifications in analysis (e.g., the "trigger effect" discussed above) and, taken together with quantitative analyses of more comprehensive data sets, is vital for developing practicable and effective amendments to the university reward system that strive to minimize unintended consequences regarding the productivity, quality, and impact of American scholarship.

Endnotes

[1]In the U.S., a series of technology transfer policies (Bayh-Dole Act, Stevenson-Wydler Act, and Cooperative Research Act) in the 1980s enhanced interaction among researchers throughout R&D organizations. In particular, some technology programs such as Advanced Technology Program (ATP) require interorganizational collaboration for funding and research. While some of the centers programs (e.g., Engineering Research Centers; Science and Technology Centers; Nanoscience and Technology Centers; Industry/University Cooperative Research Centers) of the National Science Foundation specifically require interinstitutional collaboration, it is an element of almost all their funded centers.

[2]See Etkowitz's (Etzkowitz, 2001; Etzkowitz & Leydesdorff, 2000) argument for a "second academic revolution" and Rosenberg and Nelson (1994) and Mowery (2001) for counterarguments.

[3]For an extensive review of the many different measures of technology transfer effectiveness, see Bozeman (2000).

For reviews of the distinction between MMURC activities and the activities typical to the academic department, see Bozeman and Boardman (2003, 2004a). These studies are based on more than 50 interviews with directors, faculty, and administrators from more than 20 National Science Foundation Engineering Research Centers and Science and Technology Centers.

[4]For instance, community engagement of medical faculty becomes a crucial element of the medical profession in terms workforce education, in ensuring workforce diversity, the research relevance, and its translation into practice, ensuring contributions to communities' health and economic vitality. In this context the faculty roles are changing, but the review, promotion, and tenure system (i.e., the reward system generally) has not kept pace. There is a gap between the promise of health professional schools as community-engaged institutions and the reality of how faculty members are typically judged and rewarded. One of the troubling trends currently is to evaluate community-engaged work as service rather than to consider the factors that can qualify the work as genuine scholarship (Community-Campus Partnership for Health, 2005).

[5]See http://www.erc-assoc.org/topics/6-promotion_tenure.html to review the presentation, reviewed by the authors in October 2004.

[6]There is a plethora of research making a comparable charge regarding rewarding of university teaching. See Barrett (1992), Pratt (1997), Serow (2000), Shapiro (1978), Wolverton (1998).

[7]The age groups include 20–29, 30–39, 40–49, 50–59, 60–69. We use these groupings instead of a conventional age variable (with the estimator indicating the impact of one additional year of age on the dependent variable) to better control for possible cohort

effects. However, in both versions of the models, one with the age group variable and the other with the conventional age variable, the estimators are statistically insignificant.

[8]On a four point scale, 4 = "Strongly agree," 3 = "Agree," 2 = "Disagree," 1 = "Strongly disagree."

[9]To be clear, the item was designed to be general, to elicit responses regarding the inherent value of applied versus basic research. It was not intended to measure the quality of any particular instance of research. The chief implication of this item is that some scientists, generally, may see effort towards commercial application in research as detracting from the quality of the basic research being applied.

[10]It should be noted that we isolated the discipline variables that were statistically significant and then reran the models with terms interacting our explanatory variable, tenure, with those discipline variables. Because in the second run of the models none of the interaction terms were statistically significant and did not affect the statistical significance of any other variables, including tenure, we present our original findings without inclusion of interaction terms in the models.

[11]See Kuhn's explanation of "normal science" (1996, chap. 4).

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