

Commercialization of the University and Problem Choice by Academic Biological Scientists

Mark H. Cooper

*Departments of Sociology and Rural Sociology,
University of Wisconsin–Madison*

Based on data from a survey of biological scientists at 125 American universities, this article explores how the commercialization of the university affects the problems academic scientists pursue and argues that this reorientation of scientific agendas results in a shift from science in the public interest to science for private goods. Drawing on perspectives from Bourdieu on how actors employ strategic practices toward the accumulation of social capital and acquire dispositional and perceptual tendencies that in turn recondition social structures, the commercialization of the university is construed not as something that “happens to,” but rather something that “happens through” academic scientists. The specific shape and direction of the commercialization of the university is therefore influenced by how scientists incorporate the new resources and social relations of commercialization into their scientific practice and how their creative engagement with shifting structural conditions remakes the culture of academic science.

Keywords: *problem choice; commercialization of the university; public interest; biological science; Bourdieu*

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Please address correspondence to Mark H. Cooper, Department of Geography, University of Wisconsin-Madison, 550 North Park Street, Madison WI 53706; e-mail: markcooper@wisc.edu.

Introduction

In describing the central features of the commercialization of the university, scholars have often focused on the production of proprietary outputs such as patents and start-up companies while ignoring more subtle shifts in the types and topics of research conducted. Based on data from a 2005 survey of university faculty in the biological sciences, I argue that the identification, selection, and pursuit of research problems or areas, or as it is customarily termed, problem choice, constitutes a critical component of the practice of academic research and a unique point at which the effects of commercialization on university research can be observed. This approach locates faculty as key actors through which the commercialization of the university transpires and argues that the reorientation of problem choice represents a shift in the forms of knowledge that academic biological scientists produce.

The preponderance of attention given by much of the literature on the commercialization of the university to the patent productivity and entrepreneurial intentions of university faculty (Owen-Smith and Powell 2003; Bunker Whittington and Smith-Doerr 2005; Ding, Murray, and Stuart 2006) skews representations of the broader changes affecting university research. For example, Azoulay, Ding, and Stuart (2006) argued that because faculty who patent also publish with greater frequency than faculty who do not patent, concerns that patenting has a negative effect on public research outputs are misplaced. Likewise, Foltz, Barham, and Kim (2007) identified synergies between the production of patents by academic life scientists and their performance of the traditional missions of research universities. That patenting faculty publish in academic journals at equal or greater rates than nonpatenting faculty is unsurprising though. Despite the rise of proprietary outputs such as patents and start-up companies, publications remain the primary currency of academic careers and reputations; peer-reviewed publications, unlike patents, are essential to the professional success of the academic scientist. This dominant framing of the commercialization of the university primarily as the production of tangible outputs ignores how the goals and process of research accommodate a new commercial orientation within academia. Among those topics elided by a focus on proprietary productivity is the possibility that commercial engagement by faculty reorients research agendas toward problems and solutions of interest to industry and away from public good and public interest research.

The work of Blumenthal and his colleagues (Blumenthal et al. 1986, 1996; Campbell and Blumenthal 2000) first raised the prospect of

university–industry research relationships and the redirection of research agendas. Despite using different methodological approaches, both Blumenthal et al. (1986) and Webster (1994) framed the potential effects of university–industry relations on problem choice in a similar way. Blumenthal et al. (1986, 1361) asked whether, “industrial research relationships lead faculty to shift the direction of their research toward applied or commercially oriented projects,” while Webster went slightly further, inquiring, “will this growth in industrial sponsorship change the range and direction of problems, experiments and conclusions” (1994, 124). Both Blumenthal and Webster envisioned the potential consequences for problem choice or research agendas as a direct and immediate result of industry involvement with university life scientists. As Kleinman (2003, 17) has argued though, “in addition to these direct effects . . . there are indirect, systemic effects of the commercial world on university science.” Rather than delineate between direct (structural) and indirect (cultural) forces, I examine the relationship between industrial support for research and the influence of colleagues or university administrators on faculty problem choice through a Bourdieuan approach with particular reference to concepts of *habitus*, *field*, and *illusio*. By characterizing actors as continuously acquiring dispositional and perceptual tendencies and describing how these tendencies in turn condition social relations, this approach allows the commercialization of the university to be construed as the creeping shift of cognitive, cultural, and material conditions affecting both the individual faculty and the broader university.

Study Design and Methods

Along with a team of researchers at the University of Wisconsin-Madison, I collected data used in this through a survey of a random sample of the 22,000 professorial faculty in the biological sciences at the top U.S. universities.¹ In May-June 2005, we constructed the sampling frame based on faculty directories on university Web sites from which we drew a simple random sample of 4,000, of whom 1,822 responded, yielding a response rate (adjusted for attrition from the faculty ranks) of 47.1 percent. The biological sciences were selected as the focus for our study as they are uniquely positioned between the established commercial engagements of engineering schools and agricultural colleges and the scarcity of such ties in the humanities and social sciences. The uneven and relatively recent engagement of

the biological sciences with the commercial world makes them a key site for the study of the commercialization of the university (Slaughter and Rhoades 2004). The breadth of the surveyed population (scientists at the 125 universities with the highest levels of research and development expenditures in the biological sciences 2000-2002) and the depth of respondent size (1,822 respondents) place this study in a unique position to evaluate general features of university commercialization.² This survey is the largest general survey of university biological scientists in more than ten years (Blumenthal et al. 1996) and includes all biological science disciplines, not just those disciplines presumed to be at the leading edge of university–industry relations (Campbell et al. 2002). Such data provide a needed compliment to analyses that seek broad theorization of the origins and effects of commercialization on university research and to findings derived from investigations of narrower scope conducted with individuals or at universities which may be exceptional, rather than representative, cases (Bird and Allen 1989; Owen-Smith and Powell 2001; Zucker, Darby, and Armstrong 2002).

Although the cross-sectional survey data on which this analysis is based cannot capture changes in the orientation of faculty problem choice over time, the data can be used to identify relationships between the commercial engagement of faculty and their criteria for problem choice. The analyses in this article are not an attempt to establish mechanistic causal connections between commercial engagement and a change in the orientation of faculty problem choice. I assume that the inverse of this process, where the possession of commercially oriented problem choice agenda deepens faculty engagement in commercial activities, may also be the case. More fundamentally, this paper uses Bourdieuan concepts to explain and interpret the existence of statistically significant associations between commercial engagement and a commercially oriented problem choice criteria to apprehend the role of individual faculty in broader changes in the relationship between the universities and the commercial world.³ The preference for a Bourdieuan perspective in analyzing these empirical relationships under ambiguous causal conditions is consistent both with Bourdieu's own statistical classifications of *habitus* (Bourdieu 1984), and the conception of the *habitus* as simultaneously acted upon by social conditions and generative of the individual's social action.

Public Goods, Private Goods, and the Public Interest

In this article, I argue that particular faculty engagements with the commercialization of the university are tied to the selection of problems

that biological scientists pursue and that changes within the practice of academic biological science result in a shift from science in the public interest to science for private goods. Although the notion of acting in the “public interest” has often taken on a characterization as an indefinite body of values in opposition to commercial interests, its use here refers to those activities or policies that have the potential to benefit all individuals within a given polity and which balance the needs of the entire society with individual self-interest. This use of the term “public interest,” differs in important ways from the “public goods” concept in economics that describes materials or ideas that are “nonrivalrous in use” or “nonexcludable” (Samuelson 1954). The scientific norms of communalism and open science have been described as the embodiment of this public goods concept because the dissemination of scientific knowledge from the university was supposedly accessible to all researchers without concern for ownership or profit (Heller and Eisenberg 1998; Bollier 2002; Nelson 2004). Merton and others described open science as producing public goods that generated the latent function of distributing the benefits of academic knowledge in a manner that benefited the public interest (Merton 1942; Stephan 1996).

The increasing commercialization of the university, however, has generated new pressures and incentives for academic scientists to undertake research aimed at the generation of private goods. Slaughter and Rhoades (2004) described these changes as evidence of a new “academic capitalism knowledge regime” that intersects and overlaps the existing “public good knowledge regime.” Similarly, Vallas et al. (2004, 218) argued that this reconfiguration of both university–industry relations and the organizational logics of both industrial and academic science has “generated new structures of knowledge production that defy normative traditions.” The distinction between these two regimes is not a distinction of the generation of products versus the generation of knowledge though; public good science can create useful products, and academic capitalism (or private good) science can generate basic scientific knowledge. Rather, “the academic capitalism knowledge regime values knowledge privatization and profit taking in which institutions, inventor faculty, and corporations have claims that come before those of the public. Public interest in science goods are subsumed in the increased growth expected from a strong knowledge economy” (Slaughter and Rhoades 2004, 29). The concern is not merely that the surface benefits of academic life science research are appropriated for private gain but that science oriented to the production of private goods fundamentally reorients the kinds of knowledge that academic scientists produce. In the following section, I present an exploration of the process

through which the commercialization of the university transforms faculty problem choice.

Studies of Problem Choice, Strategies of Problem Choice

The investigation of determinants for problem choice has long been a topic in social investigations of science. R. K. Merton, in his pioneering study of science in seventeenth-century England, sought to reveal, "what sociological factors, if any, influence the shifts of interest from one science to another" (1938, 364). It was through studies in the late 1970s and early 1980s by authors such as Mulkay and Edge (1973; Edge and Mulkay 1976), Gieryn (1978), Ziman (1981, 1987), and Zuckerman (1978), though, that problem choice achieved its status as a foundational concept in social studies of science. In the wake of the sociology of science's epistemological turn and its focus on laboratory ethnographies and boundary work came a deserved erosion between the presumed boundaries of science and society and also a flattened description of social relations and inattention to matters of problem choice. What has been lost by the recent inattentiveness to problem choice is the ability to perceive how reformulations of the field of academic science, such as the commercialization of the university, affect both the activities of faculty at the laboratory level and also the direction and goals of academic science in general. Before discussing the relationship of problem choice and the commercialization of the university, attention must be given to the bundle of ideas contained within the term "problem choice," how investigations of problem choice are conducted, and how problem choice sits within the repertoire of work conducted by academic scientists.

The definition of "problem choice" employed by Gieryn (1978, 97) remains the most straightforward formulation of the concept: "the decision by an individual scientist to carry out a program of research on a related set of problems or, more simply, in a problem area." The use of the word "problem" in this formulation should be interpreted loosely though. There is seldom a distinct boundary between the general domain of research, the problem area or topic including a variety of potential avenues for research, and the specific research plan or process of research undertaken in the pursuit of findings that lack preconceptual clarity. "Choice" should not be seen as a single moment where the scientist decides "what research shall I do now?" (Ziman 1981, 1) but should instead be considered a collection of the intentions, actions, and experiences that enter into the directed pursuit of scientific research.

The importance of problem choice for both the progress of personal research and the direction of science more generally comes from the ontological conditioning of the entirety of the scientific process which temporally follows. All that is considered science and the accumulated bodies of scientific knowledge proceeds from “innumerable particular decisions of individual scientists to undertake specific investigations” (Ziman 1981, 1). This contingency of findings upon initial conditions of investigation is axiomatic in philosophy of science. Sayer (1981), for example, described observation as inherently theory dependent though not theory determined.⁴ The claim that the ways in which investigators approach research problems are always affected by factors that in turn shape the conclusions at which they arrive is not in itself controversial, yet it demands attention be given to both specific factors that influence research work and the production of particular outcomes based on particular historical developments. The latter of these concerns, including both the narration of particular scientific developments and the counterfactual exploration of the roads not taken, is largely outside the scope of this article.

Despite its critical place in the practice of science, a stale dichotomy of whether problem choice can best be understood via the subjective understanding of scientists' decisions or the objective measurement of direct influences upon behavior has hindered its study. Reviewing the methodologies used by studies of problem choice, Ziman noted that many studies made use primarily of “the succession of scientific papers, on various specialized topics, that are listed in the curriculum vitae of the individual scientist” (1987, 97). By favoring evidence left after scientists had chosen their research program though, these studies struggled to apprehend scientists' reasons for particular decisions and were unable to account for the personal significance of research plans and the point of view of the individual scientist. Ziman suggested that studies of problem choice could therefore “only be explored hermeneutically by the interpenetration of introspective accounts of crucial individual decisions” (Ziman 1981, 3). This interpretive framework, also advanced by Edge and Mulkay (1976), has been criticized for conflating scientists' descriptions of what goes on in science, with what actually occurs (Gieryn 1982). One weakness of the hermeneutic approach then is that it forces researchers to take scientists' accounts of their actions at face value. Additionally though, the investigative process itself encourages the subject to retroactively rationalize his or her actions (Wilson, LaFleur, and Anderson 1996). Relying upon participant articulation of causal processes can be problematic as respondents do not have perfect access to the determinants of their actions and derive

their narration of past events from attributes that are accessible to memory, plausible, and easy to verbalize. This active cognitive reflection conveys a specific meaningfulness to past actions that is itself shaped by or produced from the interrogation of “why” particular problem choice decisions occurred.

This study adopts a new approach in its use of survey data to explore the importance of various problem choice criteria for academic biological scientists. The revealed preference analysis of faculty problem choice that this paper uses avoids the weaknesses of stated preference approaches that encourage faculty to retrospectively rationalize their behavior while allowing, unlike approaches that reconstruct choice from the archive of evidence generated after the fact, investigation of choice itself. In the survey, participants were asked to rate the importance of various problem choice criteria and the influence of various professional associates over their choice of research problems. Data on the sources of faculty research support and faculty patenting activity were also collected. Data from this survey, and all data based on self-assessment, reflect the subject’s representation of their beliefs and actions rather than the beliefs and actions themselves. It is possible, therefore, that actors’ approximation of their values will resemble the orthodoxy of their social position; that is to say, scientists may outwardly express the core values that scientists are expected to hold. For these reasons, it is important not to accept scientists’ (or any actor’s) representation of their beliefs uncritically. These expressions need not be considered intentionally deceptive or even conscious. Rather, they reflect what Bourdieu called the *illusio* or the internalized assumptions about the rules of participation and a “commitment to the presuppositions” of a certain activity (Bourdieu 1990, 66; Bourdieu and Wacquant 1992). That the responses academic scientists provided reflect their *illusio* should not be considered as an indictment of the validity of these responses, rather, its presence in the data captures a critical tension within scientists’ negotiation of their personal interests and their professional responsibilities. Indeed, Bourdieu and Wacquant note that the *illusio*, “differentiates itself according to the position occupied . . . and with the trajectory that leads each participant to this position” (1992, 117). The cross-sectional data used in this study cannot reveal this trajectory. The data can be used to develop a temporally constrained description of how the occupation of particular social positions is tied to different conceptions of the practice of academic biology. Before further discussion of how scientists publicly present their practices though, it is important to understand how the “choice” of research problems is made.

The activities scientists undertake have frequently been considered strategic practices oriented toward the accumulation of authority, professional

success, and material resources (Bourdieu 1975; 1991; Latour and Woolgar 1979; Ziman 1987; Webster 1994). Bourdieu used the term “scientific capital” to connote the various forms of “actual or potential resources” that are generated by “more or less institutionalized relationships of mutual acquaintance and recognition” that coalesce around the successful academic scientist (1986, 248). Although each individual’s strategy is simultaneously norm and context dependent, it is also oriented to the individual’s perception of how the consequences of such strategies will be viewed by other individuals acting in the same *field*.⁵ This reflexive striving differs from scientists simply making the best rational choices. Each strategic action by each participating scientist gradually remakes the field of research. Therefore, a scientist’s evaluation of a particular strategy’s merit can only be made based on a subsequent and partial understanding of its consequences and how those consequences were evaluated by other participants in the field of research. As there exists no objectively “best” decision for a scientist to make as to their research agenda, the most fitting metaphor for describing the choice of strategy is that of investment (Bourdieu 1991, 9).

Describing problem choice as an iterated strategic process does not itself advance our understanding of what influences structure its practice. Extending Bourdieu’s metaphor of investment, it is not simply the object of inquiry that is altered in the practice of research. Rather, problem choice entails scientists investing themselves in particular methodological and theoretical approaches as well as in a particular orientation to commercial and market influences. This personal investment, in addition to the investment of scientific capital, results in a continuous transformation of both the field of research and the scientist’s *habitus*.⁶ The *habitus*, or the individual’s set of cognitive and practical dispositions, is reconstructed as individuals learn from their encounters with other individuals and social structures.

It is the *habitus* of the academic scientist, in conjunction with its dyad, structure, that directs the strategic practice of problem choice. Bourdieu and Wacquant explain that “people are ‘pre-occupied’ by certain future outcomes inscribed in the present they encounter only to the extent that their *habitus* sensitizes and mobilizes them to perceive and pursue them” (1992, 26). It is crucial to acknowledge that while the individual’s *habitus* is “durable,” it is always being influenced by new experiences and reoriented by its new position in relation to social structures (Bourdieu and Wacquant 1992, 5; Bourdieu 2005, 45). Fundamentally though, characterizing actors as continuously acquiring dispositional and perceptual tendencies, and describing how these tendencies in turn condition social structures, allows the commercialization of the university to be construed

as a creeping shift of both cognitive and material conditions. By focusing our attention on problem choice as one component of a shift that both reflects and generates an increased prevalence of formal ties with industry and commercial norms in university, I maintain that the commercialization of the university is not as something that “happens to,” but rather something that “happens through” academic scientists.

This to/through distinction differentiates the Bourdieuan perspective on the commercialization of the university from more structuralist explanations that describe commercialization as an external force that impinges on the practice of academic science. The specific shape and direction of the commercialization of the university is influenced by how scientists incorporate the new resources and social relations of commercialization into their scientific practice and how their creative engagement with shifting structural conditions remakes the culture of academic science.

Industry Research Support, Patenting, and Faculty Problem Choice

Alongside the rise of biotechnology and regulatory changes encouraging the commercialization of academic research in the early 1980s, social studies of science began focusing less on functionalist explanations of academic science and more on how research agendas might be shaped by new relationships between industry and the university⁷. Nelkin, Nelson, and Kiernan (1987, 71) argued that “the new [university–industry] alliances represent a significant increase in the influence of potential commercial opportunities on decisions about research priorities.” This concern was substantiated by Blumenthal et al. in surveys of university life science faculty in 1986 and 1996.⁸ In the first survey, “faculty members with industry support were more than four times as likely as faculty without industry funds to report that such considerations had influenced their choices to some extent or to a great extent” (Blumenthal et al. 1986, 1364). The later survey similarly found that “faculty members with industrial support were [2.5 times] more likely than those without [academic industry research relationships] to report that their choice of research topics had been influenced somewhat or greatly by the likelihood that the results would have commercial application” (Blumenthal et al. 1996; Campbell and Blumenthal 2000, 133).

Using data from our 2005 survey at the University of Wisconsin-Madison, I also found evidence that scientists who receive support from industry are

Table 1
Historical Levels of Industry Support for Researchers in the Biological Sciences

Survey, Year	Percent of Total Research Support from Industry	Percent of Faculty Receiving Support from Industry	Percent of Research Support from Industry for Those Receiving Any Industry Support
Blumenthal et al. (1986)	7.4	23	34
Blumenthal et al. (1996) ^a	6.4	21	Not reported
UW-Madison, 2005	5.3	20	25

a. For nonclinical faculty only.

more likely to choose research problems based on the ability to commercialize their findings. Twenty percent of respondents indicated that they received research support from private industry within the last three years and support from private industry constituted about 5 percent of all research funding for survey respondents. Of faculty who received any industry support, private industry funds comprised 25 percent of their research budgets. These frequencies are similar to those found in earlier studies (see table 1) yet reflect use of different populations by each survey.

In our 2005 survey, faculty who received research support from industry were more than twice as likely than faculty who did not receive support from industry to indicate that potential interest by private firms in commercializing their discovery was an important factor in their choice of research problem (38 percent vs 16 percent, $p < .01$). Despite this difference, potential interest by private firms in commercializing the discovery was a relatively unimportant criteria, regardless of receipt of research support from private industry (received industry support $\bar{x} = 2.22$, no industry support $\bar{x} = 1.71$; $p < .01$; based on the scale 1 = *not important* to 5 = *very important*). Respondents who received support from private industry were also more likely to say that the potential to patent and license research findings was an important criteria in their choice or research problems (received industry support $\bar{x} = 1.89$, no industry support $\bar{x} = 1.62$; $p < .01$), though this criteria was even less important than interest by private firms in commercializing findings.

As noted above, earlier studies on the relationship between industry research support and problem choice used bivariate data to construe

Table 2
Means for Selected Problem Choice Criteria by Receipt of Industry Support (1 = Not Important to 5 = Very Important)

	No Industry Support	Industry Support	Significance
Enjoy doing this kind of research	4.67	4.60	
Scientific curiosity	4.65	4.47	***
Potential contribution to scientific theory	4.23	3.98	***
Publication probability in professional journals	3.91	3.76	*
Importance to society	3.81	4.00	**
Likelihood of clear empirical results	3.82	3.66	*
Create an environment suitable for graduate training	3.40	3.52	
Length of time required to complete research	3.02	2.94	
Potential to generate income for my laboratory	2.52	2.93	***
Likely interest by private firms in commercializing the discovery	1.71	2.22	***
Potential to patent and license the research findings	1.62	1.89	***
Industry consulting opportunities	1.41	1.87	***
Potential to create for-profit start-up from research findings	1.43	1.62	***

p* < .05. *p* < .01. ****p* < .001.

commercial influences as causing direct and immediate changes in the research practices of scientists. In contrast, I argue for the consideration of the place of the *habitus* of academic scientists as the adapt to and strategically engage in the commercialization of the university. Although there is a strong case that industry support for university research influences the kind of research problems faculty pursue, it is less clear what kind of trade-offs might exist from these circumstances. Table 2 lists the means for the importance of problem choice criteria by receipt of industry support. The most important criterion for both groups of faculty, as noted above, was “enjoy doing this kind of research.” No significant difference in means was found for this criterion. Three other criteria “scientific curiosity,” “potential contribution to scientific theory,” and “publication probability in professional journals” were rated highly by both groups of faculty as well; these criteria, however, were significantly less important for faculty who received industry funds. In addition to interest in commercialization and potential to patent discussed above, faculty who received support from industry indicated significantly more importance of “potential to generate

income for my laboratory” in their problem choice criteria. This finding confirms my earlier description of industry support as a potential resource, which scientists can translate into increased research outputs, thus furthering their accumulation of scientific capital.

To assess the relationship between patenting experience and faculty problem choice, survey participants were also asked to indicate if they had been issued a patent at any time in their academic career. Twenty-six percent of respondents indicated they had been issued a patent. Table 3 compares means for the same list of problem choice criteria between faculty with patenting experience and faculty with no patent experience. Similar to faculty who received research support from industry, faculty with patent experience rated “potential to generate income for my laboratory,” “interest by private firms in commercializing,” and “potential to patent” significantly higher than faculty who have not held patents. Although there is similarity of commercial problem choice criteria between faculty who received research support from private industry and faculty who have had patents issued, this similarity is not produced by a substantial overlap between faculty who patent and faculty who receive research support from industry. Of those faculties who received support from private industry (20 percent), only 33 percent had been issued a patent; of faculty with patent experience (26 percent), only 25 percent received research support from industry in the previous three years. Those similar variations in problem choice occur between faculty with differing kinds of engagements offers strong evidence for the effects of such activities on the disposition of academic biologists.

Perhaps the most interesting observed difference in both tables 2 and 3 was that both faculty who received support from private industry and faculty with patent experience were significantly more likely to express that “importance to society” was a meaningful problem choice criteria. Such a finding is similar to that described by Vallas et al. (2004, 226), who found that academic scientists, unlike scientists in industry, “often legitimized their research on purely intellectual grounds. For them, the virtue of curiosity-driven research seemed so firmly institutionalized, so self-evident, that they often seemed to resist any obligation to justify their research or connect it to wider social needs.” It may be, therefore, that concerns that university-industry relations have a deleterious effect on the pursuit of public interest research are misplaced. I return to this question later in the article.

Responses to four of the given problem choice criteria (likely interest by private firms in commercializing the discovery, potential to patent and license research findings, industry consulting opportunities, and potential

Table 3
Means for Selected Problem Choice Criteria by Patent Experience (1 = Not Important to 5 = Very Important)

	No Patents	Patent Experience	Significance
Enjoy doing this kind of research	4.65	4.69	
Scientific curiosity	4.60	4.67	
Potential contribution to scientific theory	4.11	4.17	
Publication probability in professional journals	3.88	3.86	
Importance to society	3.80	4.01	***
Likelihood of clear empirical results	3.77	3.89	
Create an environment suitable for graduate training	3.41	3.38	
Length of time required to complete research	3.01	2.92	
Potential to generate income for my laboratory	2.53	2.71	*
Likely interest by private firms in commercializing the discovery	1.68	2.19	***
Potential to patent and license the research findings	1.53	2.08	***
Industry consulting opportunities	1.45	1.60	**
Potential to create for-profit start-up from research findings	1.39	1.65	***

* $p < .05$. ** $p < .01$. *** $p < .001$.

to create for-profit start-up from research findings) indicate the existence of commercial priorities in faculty problem choice. To assess the existence of a broad commercial problem choice orientation, a new variable comprised by the average of these four criteria was created. Cronbach's alpha assesses the internal consistency of a construct by measuring the mean correlation and covariance across its component measures; $\alpha \geq .7$ is generally considered robust, and as α approaches 1, variance is increasingly attributed to individual cases. For the measure of generalized commercial problem choice orientation $\alpha = .876$, confirming the validity of this construct.

To evaluate the relative importance of faculty experience in commercial activities (industry funding and patent experience) on commercially oriented problem choice, I performed an ordered logistic regression, the results of which are given in table 4. The regression analysis also controls for gender, research budget, and years since degree. No assumption of a direct causal relationship for either research support from industry or faculty patenting experience and commercially oriented problem choice is implied. Rather, the existence of significant relationships between support from industry and patent experience is taken to indicate the existence

Table 4
Ordered Logistic Regression of Commercial Priorities in Faculty Problem Choice

	Coefficient	SE
Percent of financial support for research program from private industry (<i>average over past three years</i>)	0.024***	0.003
Patent issued in academic career	0.765***	0.129
Gender (<i>male</i> = 1)	0.410**	0.136
Research budget, in millions (<i>average over past three years</i>)	1.228**	0.372
Research budget, in millions ² (<i>average over past three years</i>)	-0.562**	0.189
Years since degree	-0.053**	0.020
Years since degree ²	0.001*	0.0004

Note: Log likelihood = -2,079.645.

* $p < .05$. ** $p < .01$. *** $p < .001$.

of a particular *habitus* among faculty inclined to commercialization. A Bourdieuan interpretation of the scientific field posits that faculty with prior success in patenting not only learn both practical skills useful for future patenting pursuits but become invested in the identity of being a patenting scientist. Each of these conditions predispose scientists to research amenable to commercialization and patenting and encourage the emergence of a commercially inclined *habitus* in both the individual scientists and the faculty as a whole. The regression analysis also identifies significant results of a nonlinear relationship between faculty research budgets and commercial problem choice.⁹ A larger faculty research budget is positively associated with a more commercially oriented problem choice agenda up to approximately 1.1 million dollars, after which there is an inverse relationship. That could indicate that faculty with greater resources are insulated from the pressure to commercially orient their research, it may also be the case that these faculty perceive engagement with industry as lacking the potential to contribute to their established research program. It is difficult to draw strong conclusions based on the small number of faculty (less than 3 percent of respondents) for which this applies.

Professional Relationships and Problem Choice

In this section, I assess the place of professional relationships in the determination of problem choice. Ziman (2002) claimed that the social

Table 5
Mean and Standard Deviation for Influence of Professional Associates (1 = no Influence to 5 = strong influence)

	Mean	SD
Colleagues in your university	3.21	1.19
Colleagues at another university	3.12	1.22
Colleagues from a nonprofit organization or foundation	1.79	1.14
Your immediate department supervisor	1.76	1.13
Colleagues from private industry	1.47	0.92
University administrators	1.34	0.73
Representatives of your university technology transfer office	1.23	0.59

networks within which university faculty are embedded exert strong influences over normative and professional orientations. He argued that because relationships among university scientists are simultaneously hierarchical, competitive, and cooperative, individuals must remain consistently adaptive to the expectations of others. To assess the relative importance and effects of particular associations, survey participants were asked to rate the degree of influence seven groups of people had on their choice of research problems on a scale of 1 (*no influence*) to 5 (*strong influence*). Table 5 reports the means and standard deviations for each of these groups. As the scale for influence of professional associates is not the same scale as that used for problem choice criteria, the relative influence of the two categories is not directly comparable. It is noteworthy, however, that faculty tended to rate most criteria for problem choice as important (above 3 on the 1 to 5 scale), while characterizing most professional influences as unimportant (below 3 on the 1 to 5 scale). This would seem to provide anecdotal support for Kleinman’s (2003) observation that scientists often describe their practices based on the presumption of free choice, thus downplaying the influence of structural conditions on their behavior.

Existing research on the effect of professional relationships and the commercialization of the university has focused on the influence of department heads and university administrators (who may hold a variety of titles including associate dean, vice-chancellor for research, or director of research programs; Bird and Allen 1989; Slaughter and Leslie 1997; Kleinman 2003; Vallas et al. 2004; Slaughter and Rhoades 2004). Accounts vary on both how influential administrative directives are and whether department-level administrators protect faculty from commercial pressures or encourage engagement with industry and entrepreneurial behaviors. Slaughter and

Rhoades (2004, 186), for example, claimed that they have found “no consistent evidence of department heads mentoring faculty, particularly junior faculty, in the direction of doing entrepreneurial work. . . . In fact, quite the contrary was true. In those few cases when department heads mentioned entrepreneurial research markets to new hires, they cautioned young faculty against becoming too involved with industry and private sources of research support and activity.” Vallas et al. (2004, 235), however, noted that, “many of the academic administrators we interviewed . . . seemed to have largely accepted the transformation of the university into a servant of industry.”

I again used an ordered logistic regression analysis to identify how the strength of influence (on a 1 to 5 integer scale) of each of seven groups of professional associates is related to faculty ratings of the importance of commercially oriented problem choice criteria. These analyses are not intended to reveal a direct explanatory relationship. Instead, they show that the influence of a particular group of associates is statistically associated with faculty ratings of the aggregated commercial problem choice criteria. As was the case with patenting experience above, I interpret significant relationships between commercial problem choice criteria and which associates faculty members consider influential as evidence for the existence of a *habitus* reflective of the changing culture of academic science. In table 6, the strength of influence of departmental supervisors is positively associated with the degree of importance of the commercialization problem choice criteria. This indicates that after controlling for the influence of other associate groups and demographic variables, faculty who say they were more strongly influenced by department supervisors report that potential commercialization was a significantly more important criteria for problem choice than do faculty who were less influenced by department supervisors. Even stronger associations with commercial problem choice criteria were identified with the influence of colleagues from private industry and technology transfer office representatives. The form of influence that department supervisors possess, however, would seem to fundamentally differ from that of private industry colleagues or technology transfer office representatives. Whereas all faculty and junior faculty disproportionately have relationships with department supervisors, a smaller set of faculty would have regular contact with either colleagues in private industry or their university’s technology transfer office (if such an office exists at their university.) In fact, three-quarters of faculty said that colleagues in private industry had “no influence” on their choice of research problems, and 84 percent said representatives of their technology transfer office had “no influence.”

Table 6
Ordered Logistic Regression of Commercial Priorities in Faculty Problem Choice

	Coefficient	SE
Colleagues in your university	0.054	0.049
Colleagues at another university	-0.187***	0.044
Colleagues from a nonprofit organization or foundation	0.019	0.051
Your immediate department supervisor	0.150**	0.058
Colleagues from private industry	0.515***	0.059
University administrators	0.147	0.091
Representatives of your university technology transfer office	1.113***	0.109
Gender (<i>male</i> = 1)	0.432**	0.126
Research budget, in millions (average over past three years)	1.647***	0.330
Research budget, in millions ² (average over past three years)	-0.740***	0.173
Years since degree	-0.014	0.019
Years since degree ²	-0.0002	0.0004

Note: Log likelihood = -2,360.667.

p* < .05. *p* < .01. ****p* < .001.

Although the regression analysis in table 6 does not appropriately reflect these differences between strength of ties and frequency of ties in faculty professional relationships, it clearly demonstrates an association between the influence of particular professional associates and the importance of particular problem choice criteria for university biological scientists. Attention to the lack of significant relationships between particular professional associates and commercially oriented problem choice is equally important. Contrary to expectations of the literature (discussed above), the influence of university administrators was not found to have a significant relationship with a commercial problem choice orientation. Not only did respondents indicate that university administrators were of relatively little influence (only technology transfer office representatives were less important) but the influence administrators do exert on problem choice does not appear to be strongly directed toward the commercialization of research findings or the generation of patents and licenses.

Discussion

A commonly expressed concern in regard to the increasing ties between the industry and the university is that such relationships might weaken the

university's reputation for objectivity (Press and Washburn 2000; Bok 2003; Nelson 2004). When concerns about the commercialization of academic science are framed around the "objectivity" or "purity" of science, evaluations of research policy come to depend on binary categories; research is simply "objective" or "unobjective." It has been well documented, however, that targeted support for research and institutional constraints upon research agendas were also present during earlier periods, particularly for military research during the cold war (Webster 1994; Kleinman and Vallas 2001). I suggest it is more appropriate to consider the effects of influences on the direction of academic research as a matter of "interestedness" versus "disinterestedness." Instead of a black and white distinction between objective and unobjective, which presumably also divides good science from bad science, the sources and degrees of influence upon faculty research can be envisioned as located at one of a near infinite number of positions within a color wheel. Envisioning interestedness in terms of "hue" (the sources of influence) and "saturation" (the degrees of influence) allows acknowledgment of the multiple sources and complex processes that constitute faculty problem choice. The appearance of "disinterestedness" then, can only be made in reference to the possession of different interests, thus allowing for the simultaneous presence of the state, industry, and the public, among others, in analyses of influences upon faculty research agendas.¹⁰ It is also this "disinterestedness" in relation to purely commercial and political forces that marks the university as a unique site for the cultivation of the public interest (Bourdieu 1988).

I have argued that a Bourdieuan perspective allows us to see how the commercialization of the university affects (and is itself produced through) faculty problem choice by shifting the focus of academic life scientists to a greater interest in research that generates patents or commercializable findings and away from research based on scientific curiosity and potential contributions to scientific theory. Contrary to those who claim these traditional scientific norms and the production of public goods are equivalent to science in the public interest, I found that faculty who received industry support rated "importance to society" significantly more important in their choice of research problems than those faculty who did not receive support from industry. This finding confirms the claim of Vallas et al. (2004, 220) that "rather than stressing the social benefits that ultimately accrue from support of basic research, the academic scientists we interviewed tended to employ a rhetoric of intellectual fascination and discovery, in which the value of their research ultimately rested on its personal interest and cognitive appeal . . . and ironically perhaps, it is the scientists in private industry

who stress the moral or social benefits that flow from their research.” As discussed above, however, I do not believe that scientists’ representation of their beliefs can be accepted uncritically. Attention must be given to the tendency for subjects to unconsciously represent their beliefs in the way they expect that someone in their position should respond (Mulkay 1976; Bourdieu and Wacquant 1992). Whereas Vallas et al. (2004) distinguished between the “ethical atrophy” of “anti-utilitarian” academic scientists who express the importance of scientific theory and scientific curiosity above social benefit, and industry scientists who spoke of the importance of both the private profit and the public interest, I would instead claim that both academic scientists with ties to industry and those without ties to industry use a strategic rhetoric that they believe their structural position demands. That a significant difference exists in aspirations for research to be of benefit to society between faculty receiving research support from industry may merely reflect a difference in the *illusio* between commercially oriented and noncommercially oriented scientists.

Scientists expressing an “ivory tower” orientation to academic research believe that an appeal to traditional norms, including claims as to the objectivity of their inquiry, is sufficient to maintain the orthodoxy of academic science that has existed since the Second World War. More commercially engaged scientists, however, are more likely to express the importance of market-oriented solutions. To challenge the orthodoxy of traditional scientific norms which disparage direct ties between the industry and the university, these scientists justify their activities with a rhetoric of increased public benefit. I do not believe that this activity should be seen as a cynical calculation aimed at legitimating new forms of academic practice, though this may be the case in some instances. We have no reason to doubt that these engaged scientists genuinely believe that for their work to have practical application and subsequent public benefit, patenting, licensing, and commercialization through industry are necessary. It is scientists’ internalization of this idea that the importance of a particular finding to society is tied to its potential for profit that is most revealing about the effects of commercialization on problem choice in academic life science. This notion, that the mission of the university includes the production of private goods or the generation of public goods such as new products and economic development, reflects an instrumental justification for the abdication of the value-rational roles in the public interest, which traditionally been fulfilled by public and private universities alike (Calhoun 2006).

Problem choice constitutes a critical juncture at which the various influences upon scientific research are open to investigation. The debate on the

commercialization of the university has given insufficient attention to how both the direct influences, such as sources of research support, and the indirect influences, such as faculty's social ties with professional associates, affect problem choice by academic life scientists. These influences play a critical role in the kind of scientific research done within the university and whether this research is directed at the generation of private goods or the public interest. Additionally, this approach locates faculty as key actors in the commercialization of the university. Further attention to how faculty translate these influences into the setting of their research agendas could strengthen this new perspective that challenges the description of commercialization as an external force impinging on the practice of scientists and corrupting the objectivity of academic inquiry. Future research following the career development of academic scientists and their engagement with commercialization could develop this perspective more thoroughly and draw upon the dynamism inherent in Bourdieu's approach.

Notes

1. Jeremy D. Foltz, Bradford L. Barham, Timo Goeschl, Frederick H. Buttel, Jessica R. Goldberger, and Mark H. Cooper.

2. For the purposes of this study, the biological sciences are those defined by the National Center for Education Statistics (NCES) and the National Science Foundation (NSF; National Science Foundation 2004). NCES and NSF categorize biological science as a subset of a more general category, life science, which also contains agricultural science and medical science. Research and development expenditures come from National Science Foundation (2002).

3. Bourdieu himself advocated reading statistical data through particular theoretical lenses. He claimed that "statistical data, whilst they are concerned with the manifestation or consequences of an attitude which contains within itself something comprehensible, are only 'explained' if they are really interpreted in a manner which reclothes the particular case with meaning." Conversely, he argued that statistical data were useful check on explanatory schemes: "the cleverest and most intelligible hypotheses must not receive greater weight, proportionately, than the proportion of the phenomena and of the individuals of which they offer an account. Statistics forces the sociologist to assign a 'weighting' to his hypothesis" (Bourdieu 1963).

4. Theory is described here as general dispositions, conditions, and orientations not as subscription to any particular theoretical regime. See Hanson (1958) and Lakatos and Musgrave (1970) for the development of this idea.

5. My use of *field* reflects both Bourdieu's notion of a "space of competition where agents or institutions who work at valorizing their own capital . . . confront one another" (Bourdieu 1991, 6), and the particular terrain or area of study of each academic discipline.

6. Bourdieu describes the *habitus* as, "schemes of perception, appreciation and action, produced by a specific form of educative action, which make possible the choice of objects, the solution of problems, and the evaluation of solutions" (Bourdieu 1975, 30).

7. See Busch and Lacy (1981) and Busch, Lacy, and Sachs (1983) on land-grant agricultural colleges; Blumenthal et al. (1986) on medical and life sciences; and Kenney (1986) and Curry and Kenney (1990) on biotechnology in both agricultural and life science.

8. Notable differences exist between the survey population of this study and the Blumenthal studies. Blumenthal et al. (1986) and Blumenthal et al. (1996) surveyed faculty at forty and fifty universities, respectively, and surveyed faculty in a narrower range of “biotechnology” disciplines. These studies also included a higher frequency of clinical faculty than does this population. Clinical faculty tends to receive greater levels of industry support than do nonclinical faculty.

9. I thank a reviewer for raising the importance of this finding.

10. This framing of the question of interestedness and disinterestedness in terms of influences on the academic *habitus* and criteria for problem choice does not mean that scientists are ever disinterested in the strategic accumulation of various forms of capital within their *field* (see Bourdieu 1991, 8; Bourdieu and Wacquant 1992, 26). Rather, my suggestion here is that overlapping and complex sources of influence on the academic *habitus* will manifest themselves through different problem choice orientations. I thank a reviewer for raising this point.

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Mark H. Cooper is a PhD student in the Departments of Sociology and Rural Sociology, University of Wisconsin–Madison. His research interests lie in the political sociology of science, emerging regimes of scientific governance, and the geographies of scientific knowledge production.