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Unintended consequences of cooperative research: impact of industry sponsorship on climate for academic freedom and other graduate student outcome

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Abstract

The research policy community has produced a significant body of empirical research on benefits of cooperative research between industry and university. However, in spite of a lively policy debate on the subject, it has all but ignored empirical study on the ''costs'' or unintended consequences of these activities (e.g., erosion of academic freedom). In fact, only four empirical articles assessing various ''costs'' were found in the literature. The current study attempted to inform the debate about benefits vs. costs of cooperative research by examining the impact of source of funding (industry, government and no external sponsor) and form of funding (single source, consortial, or unfunded) on a variety of research processes and outcomes for a particularly vulnerable population — graduate students; it also involved the development and evaluation of a measure of ''climate for academic freedom''. The study used a purposive stratified sample of graduate students from the same two engineering departments at six US universities ($N = 482$). Although some minor differences were found, the results failed to support claims that sponsorship by industry negatively affect student experiences or outcomes. Consistent with the predictions of some observers, the most striking differences were observed between sponsored projects and projects with no external sponsor. Exploratory analyses identified several variables that do explain differences in perceived ''climate for academic freedom''. Implications of these findings for research policy and future research on unintended consequences are discussed.

Keywords: Cooperative research; University and industry cooperation; Academic freedom

1. Cooperative research and public policy

Efforts to promote research cooperation and interaction between industry and university have been one of the most stable and widely supported elements of US science and technology (S&T) policy over the past three decades. Virtually every presidential administration since Nixon has supported policy and/or programmatic initiatives to strengthen ties between these two sectors and that support continues to up to the current administration (Clinton, 1993). These initiatives have included a variety of legislative reforms including the Bayh–Dole Act (Moore, 1988), the Economic Recovery Tax Act of 1981 and 1986 (Roessner, 1989) the Stevenson-Wydler (1980) and National Cooperative Research Act of 1984

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(Langenfield and Scheffman, 1989). These efforts have also included a variety of programmatic attempts to directly stimulate industry–university cooperation through various subsidized partnership programs (e.g., Bloch, 1986). The federal government has not been alone in targeting cooperative research. Over the past two decades state governments have also been very active in this area (Carnegie Commission on Science, Technology and Government, 1992).

To a large extent, support for these initiatives has been premised on a belief that increased and more intense cooperation between these two sectors will lead to a variety of benefits including increased support for academic research, increased and accelerated technology transfer, enhanced competitiveness, and, ultimately, economic development. The research policy community has contributed to these efforts by examining whether these benefits have in fact been delivered. For instance, there is a great deal of evidence that industry has in fact increased its support of academic research. Industry now supports almost 7% of all university research, nearly double the amount it supported during the early 1980s; the number of institutions receiving over 10% of their research support from industry has also doubled (National Science Board, 1996).

However, since many government-sponsored cooperative research programs involve financial cost sharing, government initiatives have also amplified industry's influence. According to Cohen et al. (1994), the vast majority of the 1100 university–industry centers and institutes they were able to identify also received support from federal and/or state sources. These centers spent over US$2.5 billion in R&D during the fiscal year studied or roughly 15% of total academic R&D expenditures. Add to this, the industry support not channelled through centers, and industry probably influences 20% to 25% of academic research.

A significant literature has also evolved around the technology transfer and economic development benefits of cooperation. These efforts are reviewed in much greater detail elsewhere (e.g., Coburn, 1995; Lee, 1996; Feller, 1997; Gray et al., 1997). While it is still too early to provide definitive answers, enough solid empirical research has been completed to allow observers to draw some reasonable if cautious conclusions. For instance, while he found little evidence of a direct and measurable impact of cooperative research centers on economic development, Feller (1997) concludes:

> University–industry cooperative R&D programs have become the dominant form of industry support of academic R&D. Both industrial and university participants report a broad set of benefits for these centers, including patents and licenses, but extending well beyond these markers of technology transfer (p. 54).

While these conclusions are encouraging, the research policy community has been remiss in addressing the other half of the policy debate — the potential costs of these cooperative arrangements.

2. Revisiting the policy debate: recognizing the potential costs of increased cooperative research

> University scientists in some fields of physics, chemistry and biology have long been involved with commercial applications of their research, especially since the end of World War II. However, there has been little systematic evaluation or historical analysis of the effects of these experiences on the university, on the research environment, on the direction and quality of basic science or on the scientists themselves. (Weiner, 1982; p. 88)

The policy debate about unintended negative consequences came to the forefront during the early 1980s, when the US House of Representatives convened a hearing entitled, ''Commercialization of Academic Biomedical Research''.

Derek Bok represented one side of the issue in his remarks in a 1981 address at Harvard when he expressed:

> an uneasy sense that programs to exploit commercial developments are likely to confuse the university's central commitment to the pursuit of

> knowledge and learning by introducing into the very heart of the academic enterprise a new and powerful motive — the search for utility and commercial gain. (Bok, 1981; p. 26)

However, not everyone has shared Bok's pessimistic assessment. Dr. Lamont-Havers, Director of Research, Massachusetts General Hospital, in his remarks to the committee, expressed the following opinion:

> In many respects, I believe that the arguments which are going on now within academia, the soul searching, the concern of the impact [of] industry on academia, how this is going to destroy values is very reminiscent of the same type of arguments which went on 20 or 25 years ago when large amounts of Federal funds began to flow into the academic institutions. (US House of Representatives, Committee on Science and Technology, 1981; p. 90)

Echoing this view, Omenn later wrote:

> To be realistic and not too romantic about the often-troubled past, we should note that universities have found themselves negotiating over or adjusting to requests and requirements of the funding source, whether wealthy individuals, foundations, industry, or government. (Omenn, 1983; p. 21)

Since cooperative research has grown enormously over the past several decades, the issues raised by these observers have continued salience. In the remainder of this paper, we examine what has been learned about unintended consequences of cooperative research and describe a study that attempts to address some unresolved issues.

3. Research on unintended consequences of cooperative research

A variety of prominent journals on S&T policy, evaluation research and higher education were examined to identify quantitative or qualitative research studies (as opposed to opinion or theory pieces) which addressed the costs or unintended consequences of cooperative research. [1]

Relevant studies can be grouped into three categories: journalistic ''case studies'', studies that identified conditions that might lead to unintended consequences, and empirical studies that examined whether unintended consequences actually occurred. Journalistic case studies and studies of conditions that might promote conflicts are relatively common. For instance, *Science* and the *Chronicle of Higher Education* regularly feature stories on controversial cooperative research initiatives. However, these pieces generally point out potential not actual unintended consequences (e.g., Cuilliton, 1982; Blum, 1991). Similarly, a number of studies have examined whether cooperation creates conditions that might predispose faculty to ethical or value compromises, or otherwise distort faculty behavior. For instance, Cohen et al. (1994) report that approximately 35% of industry–university research centers allow firms the ability to delete information from center reports and over 50% allow the right to delay publication. Blumenthal et al. (1986a; b) report a similar finding. Campbell (1997) reports that faculty who were engaged in collaborative activities were more likely to be supportive of various practices which might lead to conflicts (e.g., exclusive licensing of technology) than non-collaborating faculty on one of three scales: financially based conflicts. While these reports have caused some to react with alarm, others have cautioned that the potential for problems and the growth of supportive conditions are not prima facie evidence of negative effects (Lee, 1996).

Unfortunately, since we were only able to find four empirical studies which addressed unintended consequences and their findings are not completely consistent, we are still a long way from resolving this debate.

[1] Issues of the following journals were reviewed for at least the past 5 years: Research Policy, Engineering Education, Journal of Higher Education, Research in Higher Education, Science, Technology and Human Values, Technological Forecasting and Social Change, Technology in Society, Evaluation Review, New England of Medicine, Journal of the American Medical Association. Articles in some earlier issues and from other sources were identified from reference lists.

Allen and Norling (1990) conducted a survey of almost 400 faculty at 4-year higher education institutions in Pennsylvania. Most of the respondents held positions in science and engineering programs; two-thirds were tenured. Their study attempted to determine if involvement with industry via consulting, industry-sponsored research and start-up or some combination of these activities would affect institutional priorities, teaching and other academic activities and a desire to leave the university. While their results did not include a statistical analysis of their data, their study sheds some light on these issues and demonstrates the feasibility of conducting research on this topic. First, ''supercommercial'' faculty, faculty involved in client-based, consulting and start-up activities, appeared to be as involved as other faculty in university activities and devote a comparable amount of time to those activities. Second, most faculty involved in commercial activities resembled faculty not involved in such activities in terms of perceived relevance of various traditional goals like publishing, generating pure knowledge, etc. Finally, the more faculty were involved in commercial activities, the more likely they were to report that the commercial potential of their research could motivate them to leave academe. (Since faculty who are not involved in commercial research are unlikely to have such an opportunity, the significance of this finding is not clear.) Thus, while limited in scope and methodology, this study suggested faculty who were actively collaborating with industry continued to be engaged in a full complement of academic endeavors and to support the relevance of traditional academic goals.

However, a study by Gluck et al. (1987) provided some cause for alarm. They reported that students with direct support from industry (e.g., scholarships, salary or research support) reported fewer publications, were more likely to report perceived constraints on discussing their work and to believe that their industry sponsor placed some restrictions on them.

A more recent study by Blumenthal et al. begins to show how complicated the relationships between funding support and various outcomes may be. Their findings are reported in two papers based on survey of a stratified national sample of 2167 clinical and non-clinical life science faculty. In the first paper (Blumenthal et al., 1996), they report that faculty who received research support from industry reported more publications, greater participation in service activities and a higher publication trends than faculty without industry support. A more detailed analysis indicated that faculty who received over two-thirds of their support from industry reported fewer publications, less service and lower publication influence ratings than faculty with low or moderate support from industry. However, it is worth noting that faculty with high industry support still appeared to be performing at a rate comparable to faculty with no industrial support. They also found that faculty who received industry support were more likely to report that their choice of research topic was influenced by the project's commercial potential.

In a separate multivariate analysis of data from the same dataset (Blumenthal et al., 1997), they report a finding that delaying publications longer than 6 months was predicted by two variables: receiving funding from industry and being involved in commercialization activities. Refusing to supply other researchers with research results or materials was predicted by three variables: being involved in commercialization activities, genetics research and higher publication rates. While these findings are intriguing, they present a complex and somewhat contradictory pattern of effects. Further, it is unclear if these results would generalize to fields not subject to the proprietary commercialization pressures currently operating in the life sciences and biotechnology.

While the small number of studies found was disappointing, this outcome is not inconsistent with attempts to find empirical research on ethical or value issues on non-student populations within higher education. For instance, Counelis (1993) reported that he could find ''no empirical research on the university's moral deportment'', and ''no empirical studies on ethical behavior in American higher education''. [2] While it is tempting to excuse this failing to the methodological difficulties inherent in study-

[2] Our review, however, surfaced two such studies: one on factors that influence personal responses to observed scientific misconduct (Braxton and Bayer, 1996) and another somewhat dated study that asked faculty about their knowledge and compliance with secrecy (Etnier, 1986).

ing ethical and value-laden issues, there is a healthy tradition of empirical research on these issues in the business community. [3]

Thus, based on our review, we would have to agree with others who have evaluated the research on the unintended consequences of cooperative research:

> The issues have not gone away. A review of technology transfer outputs and outcomes, other than highlighting continuing and building university engagement, is not itself an examination of these concerns or of whether universities have learned how to correctly balance multiple objectives and commitments. (Feller, 1997; p. 56)

> Despite the plethora of literature on the subject of university/industry cooperative research which usually concludes with a critical opinion, very few, if any, in-depth studies exist on the subject. (Blevins and Ewer, 1988; p. 655)

4. Recent discussions of unintended consequences

Not surprisingly, given the paucity of data available, the debate on the likelihood and significance of various unintended consequences of cooperative research has not subsided. For instance, a variety of observers continue to raise concerns about the impact of cooperative research on the university's core value structure, including universalism, communism (making knowledge freely available to all), disinterestedness and organized skepticism (Kenny, 1987) and academic freedom (Slaughter, 1988). Other concerns have also been raised including, potential decline in the amount of basic research performed (Kenny, 1987; Brooks, 1993) and the likelihood that faculty will be lured away from academe (Kenny, 1987).

This does not mean everyone agrees with these concerns. Some contend a variety of factors, such as the small amount of funding provided by industry, the power of the imperative to publish, the heterogeneity of funding sources, the similarity of industry's goals to government mission-driven and defense agencies, and efforts by universities to respond to various pressures, will mitigate against unintended consequences (Schumacher, 1992).

While some may be willing to write this debate off as academic self-absorption, others believe the potential of unintended consequences may ultimately affect the performance of our innovation system and, therefore, have important policy significance. For instance, a number of authors suggest a decline in the amount of basic research conducted and incipient secrecy resulting from increased cooperation may actually undermine the innovation process (Kenny, 1987; Feller, 1997). As Kenny (1987) puts it, ''. . . [S]hould it not be expected that further generations of technological innovations will be slowed as increasing numbers of scientists remain in their university chairs and yet devote their energies to commercial activities?'' (p. 34). If concerns about erosion of academic freedom are borne out, it may also trigger a backlash that will undermine the very enterprise of cooperation. According to the research by Lee (1996), over 65% of the faculty he surveyed felt it was possible that university–industry collaboration could affect academic freedom. Based on his multivariate analyses, such concerns are the single best predictor of a reluctance to support user-oriented research and commercialization activities.

While the debate on the likelihood of unintended consequences from cooperative research continues, there is little agreement on the need for more research on this issue. Even those who point out troubling developments, like increased acceptance of publication delays admit that there is no hard evidence that these policies have been widely enforced or had a negative effect (Brooks, 1993; Cohen et al., 1994; Lee, 1996). Not surprisingly, a number of authors have pointed out the need for more empirical research to sort out various claims and counter claims (Blevins and Ewer, 1988; Counelis, 1993; Lee, 1996).

In the current study, we try to respond to these pleas with a study which looks at unintended consequences of cooperative research on an important and particularly vulnerable population — graduate students.

[3] The reader is referred to the Journal of Business Ethics for examples.

5. A focus on graduate students

Although graduate students are shielded from some of the more controversial forms of cooperation like involvement in start-ups and holding equity in a firm, in some ways, they are an ideal population for a study of the unintended consequences of cooperative research. In many instances, it is students rather than faculty who actually conduct the research. Further, access to students trained in industrially oriented research is one reason often given by firms for participating in cooperative research (Peters and Fusfeld, 1982).

In fact, many of the concerns raised about the impact of cooperative research have highlighted the potential for untoward effects on graduate students. For instance, Etnier (1986) argues that ''If a scientist begins a career working under secretive conditions, that will become her norm'' (p. 268). While acknowledging that faculty have choices about their involvement in commercially oriented research, Helwig (1988) points out ''That is not always true of the graduate students acting as their research assistants, who may be forced to compromise their academic careers to business interest'' (p. 82). Kenny (1987) highlights three ways in which corporate involvement may compromise a student–teacher relationship: the instructor might neglect his/her supervisory duties, the instructor might direct students into areas useful to his/her firm and use them as a low-paid employees or might transfer the unpublished results of a student's work to his/her company. Finally, Blevins and Ewer (1988) cautions that corporate involvement might coax students to choose lucrative business interests rather than a career in academia.

In sum, there appears to be a variety of relevant policy questions unanswered about the unintended consequences of cooperative research for graduate students.

5.1. Study objective / questions

Our overall objective was to examine whether the source and form of funding for graduate student research was related to differences in research experiences or outcomes. Since the published research does not provide a basis for hypothesis testing, we attempted to address one measurement objective and two research objectives.

Measurement objective:

(1) To develop a psychometrically sound measure of ''climate for academic freedom''.

Research objectives:

(2) To assess whether the source or form of research funding is associated with the structure or nature of a student's research experience.

(3) To assess whether the source or form of research funding is associated with various outcomes, including the perceived ''climate for academic freedom''.

6. Methods

The study was sponsored by the National Science Foundation's Industry/University Cooperative Research Centers (I/UCRC) Program of the Division of Engineering Education and Centers. The I/UCRC program provides support for university-based industrially sponsored research (Gray and Walters, 1998). Data were collected via a mail survey of a purposive

Table 1
What is the rank of the faculty member with whom you work most closely?

	N (%) sample	*N* (column %) by source			*N* (column %) by form		
		Industry	Government	No external sponsor	Single	Consortial	Unfunded
Full	266 (55.6)	112 (51.8)	106 (65.4)	48 (48.0)	166 (58.4)	70 (51.5)	30 (51.7)
Associate	125 (26.7)	59 (27.3)	37 (22.8)	29 (29.0)	73 (25.7)	37 (27.2)	15 (25.9)
Assistant	68 (14.2)	39 (18.1)	8 (4.9)	21 (21.0)	33 (11.6)	24 (17.6)	11 (19.0)
Other	19 (3.9)	6 (2.8)	11 (6.8)	2 (2.0)	12 (4.2)	5 (3.7)	2 (3.4)

Table 2
Is this faculty member tenured?

	N (%) sample	N (column %) by source			N (column %) by form		
		Industry	Government	No external sponsor	Single	Consortial	Unfunded
Yes	338 (70.7)	144 (66.7)	132 (81.5)	62 (62.0)	216 (76.1)	86 (63.3)	36 (62.1)
No	104 (21.7)	55 (25.5)	22 (13.6)	27 (27.0)	56 (19.7)	36 (26.5)	12 (20.7)
Do not know	36 (7.5)	17 (7.9)	8 (4.9)	11 (11.0)	12 (4.2)	14 (10.3)	10 (17.2)

sample of graduate students. [4] A multi-stage sampling procedure was used.

6.1. Sampling

The first stage of sampling involved selecting universities. Because of our focus on research-based interactions, the sample was limited to top 100 R&D universities. Because of the study's sponsorship, the sample was limited to universities that participated in the I/UCRC Program ($N = 18$). [5] Since even the top R&D universities vary on how much research they perform for industry and these differences may reflect deep rooted cultural differences (Lee, 1996), universities were stratified by percentage of R&D funding obtained from industry. Two high (16–20%), two medium R&D (6–15%) and two low (2–5%) industry R&D universities were included in the sample.

The next stage of sampling focused on disciplines and departments. Disciplines differ, sometimes dramatically, in their engagement with and attitudes toward industry (Counelis, 1993; Braxton and Bayer, 1996; Lee, 1996). In order to conserve statistical power, the sample was limited to engineering. Because intradisciplinary differences may also operate, the sample was limited to the same two engineering departments, chemical and electrical, within each of the selected universities. The final stage of the sampling addressed individual respondents. All graduate students in these twelve departments (two departments at each of the six universities) were surveyed. Eight hundred twenty-four (out of 1939) usable completed questionnaires were returned, for an overall response rate of 42.5%. [6] This is about average for single-mailing surveys (Fowler, 1993).

Since we were primarily interested in research interactions, two subgroups of students were identified using two key questions. One question was which degree the student was currently working towards (MS, Other Masters, or PhD). The second question, answered only by MS students, was whether or not they intended to pursue a PhD. Responses to these two items were used to discriminate between two subgroups of students: those who have a research orientation (MS continuing or PhD, $N = 623$) and those who intend to stop with a Masters degree and are therefore not oriented toward research careers ($N = 170$). [7] Additional respondents were eliminated because they either had not had a research experience during the past year or reported a sponsor category that could not be reliably coded. [8] The final sample include 482 respondents.

National data by discipline were available for two variables: gender and nationality. Although this data may not exactly represent top 100 R&D institutions, it provided an opportunity to evaluate the representativeness of our sample. While there were no significant differences on gender (Female: sample = 14%; population = 15%) our sample included more US citizens than the population (Citizens: sample = 65%; population = 49%; $\chi^2(2) = 34.8$; $p < 0.001$).

[4] Data were collected during 1988–1989.

[5] In fact, since over half of the top 100 R&D universities have had an I/UCRC and over 80% of all I/UCRCs fall into the top 100 institutions, these selection criteria overlap considerably.

[6] Response rates ranged from a high of 69.8% to a low of 11.9%. The low rate occurred in a department where two other surveys of graduate students were being conducted concurrently.

[7] Data for 31 students were missing for these variables.

[8] It was discovered that the category ''other university-based center'' could involve industry or university sponsorship and single or consortial format. Since it could not be reliably coded, it was dropped from these analyses.

Table 3
Does this faculty member receive support from industry?

	N (%) sample	N (column %) by source			N (column %) by form		
		Industry	Government	No external sponsor	Single	Consortial	Unfunded
Yes	351 (73.3)	168 (77.8)	121 (74.2)	62 (62.0)	215 (75.4)	100 (73.5)	36 (62.0)
No	44 (9.1)	12 (5.6)	14 (8.6)	18 (18.0)	24 (8.4)	9 (6.6)	11 (19.0)
Do not know	84 (17.5)	36 (7.5)	28 (17.2)	20 (20.0)	46 (16.1)	27 (19.8)	11 (19.0)

6.2. Data collection

Heads of the selected departments were sent a letter describing the proposed study and were asked to provide a mailing list for all graduate students. This letter was accompanied by one from the NSF I/UCRC Program officer, encouraging cooperation. The letter was followed up by a telephone call to answer any questions and ascertain willingness to participate. Questionnaires were individually addressed to students (with a cover letter from the investigator) and mailed to the department for the ten departments where a student mailbox system could be used. [9] For two departments, questionnaires were sent to students' home addresses. In order to assure students of the anonymity of responses, a postage-paid post card was included, which they returned separately in order to have their name removed from the reminder list. A follow-up postcard was sent to students who did not respond within 3 weeks.

6.3. Instrumentation

Consistent with the study objectives, the survey instrument included items designed to capture data in four domains: (1) student descriptors; (2) sponsorship; (3) research structure and processes; and (4) outcomes.

6.4. Student descriptors

As we pointed out above, little is known about graduate student involvement in cooperative research, including which students get involved in these activities. Therefore, we measured a number of student characteristics, including age, sex, citizenship, degree currently sought (MS or PhD), number of years in program, grade point average, and prior work experience in industry (yes/no for full-time/part-time, cooperative education or internship).

6.5. Sponsorship

Unfortunately, much of the debate about the unintended consequences of cooperative research have suffered from what methodologists like Paul (1967) long ago termed the ‘‘myth of homogeneity’’. That is, critics and supporters alike have assumed that sponsorship per se makes a difference, as opposed to the form that the sponsorship takes. However, there is reason to believe the form or mechanism of the interaction does matter (Allen and Norling, 1990). For instance, our own research (Gray et al., 1986) has demonstrated that two different types of partnerships (one-on-one; consortial) resulted in dramatically different sets of goals for participating faculty and industry. As a consequence, we set out to develop a sponsorship measure which would reflect both the source and the form of the sponsorship.

Respondents were asked to indicate the funding mechanism for the project they were most involved in during the past year (not funded, other university funds, a civilian government agency, a defense agency, a single company, an NSF I/UCRC, other university-based center, a non-university based research consortium, or ‘‘other’’). These mechanisms were then collapsed to create two different independent variables: *source of sponsorship* and *form of sponsorship*.

Source of sponsorship included: no external sponsor (20.9%; not funded and other university funds), industry (45%; NSF I/UCRC, single company, and non-university based research consortium) and gov-

[9] The letter listed the sponsor of the study as the National Science Foundation. The I/UCRC program was not identified as a sponsor.

Table 4
Is this your thesis or dissertation research?

% Yes sample	% Yes by source			% Yes by form		
	Industry	Government	No external sponsor	Single	Consortial	Unfunded
85.18	89.9	81.0	82.0	83.9	91.9	75.9

ernment (34%; civilian and defense government agency is identified as a sponsor) [10]. Clearly, involvement in unsponsored research is the exception for graduate students in these departments. Form of sponsorship included: not funded (12.3%), consortially or multi-party funded (28.4%; I/UCRC or non-university based consortium) and single-source (59.3%; other university funds, single company, civilian government agency, or defense government agency). The distributions of these variables are presented in Appendices A and B, respectively.

6.6. Research structure and processes

Students were asked to describe objective and subjective aspects of their research involvement. All questions referenced the project students indicated they had spent the most time working on over the past year (e.g., the same project for which sponsorship data was obtained).

Objective aspects of their research involvement included: descriptors of their faculty advisor (rank, tenure, industrial support), how they got involved in this project (assigned, chose, developed, other), frequency of contact with project sponsor, and duration of this project.

Subjective aspects of their research involvement included: perceived nature of the research (five-point semantic differential format for applied/basic, broad/narrow, short-term/long-term, innovative/routine; coded 1–5); perceived influence of their faculty advisor, the research sponsor, and themselves on overall project direction and emphases, research methods, and interpretation and evaluation of results (1 = no control, 5 = complete control).

6.7. Outcomes

Several outcome measures were obtained. One set of items dealt with concrete outcomes like number of patents (granted and applied for), trade secrets/proprietary results, publications in refereed journals, and presentations at conferences/scientific meetings. Students indicated (yes/no) if their research had resulted in any of the above, and if yes, the number.

A second outcome measure related to students' career objectives. These questions focused on the kind of employer (industry, government, university, other) the respondent intended to pursue after graduation.

A third outcome of interest in the present study is ''climate for academic freedom''. We describe the development of this measure in Section 7 (see Section 7.1).

6.8. Analytic strategy

A variety of statistical methods were used including: basic descriptive statistics, factor analysis, reliability assessment, correlational analysis, contingency table analysis (chi-square), analysis of variance [11] and regression analysis.

7. Results

The discussion of results is organized by research objective. Given the large number of tests of significance, alpha was set at a more stringent 0.01. Post hoc analyses were done with Scheffe tests or further

[10] The percentage receiving support from industry while high seems consistent with recent reports (Cohen et al., 1994) that indicate 15% of all university funding comes from university–industry centers alone.

[11] Since the focus of this article is on the effects of industry funding, results are not reported herein for analyses across levels of R&D funding or between departments. Our analyses indicate that the effects of source and form of funding (see Section 7) were independent of these two sampling variables.

Table 5
How did you get involved with this project?

	N (%) sample	N (column %) by source			N (column %) by form		
		Industry	Government	No external sponsor	Single	Consortial	Unfunded
Assigned	147 (30.7)	61 (28.4)	48 (29.4)	38 (38)	83 (29.1)	42 (31.1)	22 (37.9)
Chose	208 (43.5)	95 (44.2)	73 (44.8)	40 (38)	122 (42.8)	61 (45.2)	25 (43.1)
Developed	101 (21.2)	48 (22.3)	33 (20.2)	40 (20)	61 (21.4)	29 (21.5)	11 (19.0)
Other	22 (5.0)	11 (5.1)	9 (5.5)	2 (2)	19 (6.7)	3 (2.2)	0 (0)

chi-square analysis, as appropriate, using an alpha of 0.05.

7.1. Objective 1: To develop a psychometrically sound measure of ''climate for academic freedom''

One of the major obstacles to conducting empirical research on the unintended outcomes of cooperative research is that the really important outcomes under discussion (constructs like institutional mission, value systems, and academic freedom) are abstract organizational-level constructs. While most social scientists talk about and believe that organizations have recognizable and different ''cultures'' and/or ''climates'', many believe these qualities cannot be measured empirically or objectively. As a consequence, these outcomes are examined impressionistically or not at all.

However, there is a rich body of empirical research, mostly from organizational psychology, on organizational climate; in fact, the concept has been little researched in recent years because it has ''died from acceptance'' (Schneider, 1985; p. 595). An early review by James and Jones (1974) suggests that while organizational climate may be a characteristic of the organization, it can be assessed by means of ''perceptual'' measurements. In this paradigm, individual perceptions of various features of the organization or group are averaged to measure the climate. This approach emphasizes that individual psychological processes mediate between ''objective'' organizational features (such as size, structure, reward systems, etc.) and outcomes (such as productivity, etc.). Subsequently, researchers have focused on climate for something (e.g., safety, service, training, etc.) (Schneider, 1990), taking into account that

Table 6
Influence on research

	Sample mean	Mean by source			Mean by form		
		Industry	Government	No external sponsor	Single	Consortial	Unfunded
Overall direction and emphasis							
Sponsor	2.17	2.21	2.29	1.86	1.94	2.21	2.19
Faculty advisor	3.54	3.64	3.40	3.53	3.41	3.62	3.52
Student	3.78	3.86	3.72	3.72	3.81	3.82	3.76
Other	2.34	2.04	2.95	2.00	2.0	2.0	2.74
Project research methods							
Sponsor	1.73	1.74	1.71	1.73	1.81	1.79	1.68
Faculty advisor	3.39	3.48	3.29	3.35	3.26	3.50	3.36
Student	3.97	4.05	3.94	3.88	3.91	4.07	3.94
Other	2.38	2.30	2.61	2.22	1.86	2.18	2.71
Interpretation and evaluation of results							
Sponsor	1.80	1.87	1.73	1.75	1.87	1.90	1.74
Faculty advisor	3.51	3.59	3.35	3.61	3.63	3.61	3.43
Student	4.03	4.07	4.05	3.93	3.96	4.03	4.05
Other	2.24	2.06	2.45	2.33	1.86	2.0	2.62

Table 7
Number of discussions with research sponsor

	Sample mean	Mean by source			Mean by form		
		Industry	Government	No external sponsor	Single	Consortial	Unfunded
Number of discussions	2.46	2.72	1.41	3.90	2.04	2.73	4.30

people make sense of clusters of related events. Consistent with this framework, we set out to develop a psychometrically sound measure of ''climate for academic freedom''.

Our measurement approach was based on the rational and empirical scale development strategy of Jackson (1970). First, the literature was reviewed to identify dimensions of academic freedom. Next, an informal survey of faculty to identify and define dimensions was conducted. These activities suggested three dimensions: freedom to choose methods/questions, freedom to communicate results, and freedom to interpret results.

During the rational steps in the scale development process, a pool of items was developed for each dimension and discussed informally with faculty and graduate students. These items were reviewed for social desirability bias and balance of positive and negative items. Fifteen items were selected for inclusion. These items, along with the entire draft of the questionnaire, were reviewed in a structured group discussion with engineering graduate students and revised based on their feedback.

Empirical steps in scale development involved factor analysis, evaluation of reliability, and correlational analysis. The 15 variables were factor analyzed using principal components factor analysis with orthogonal rotations. [12] These analyses suggested a two factor solution: freedom in conducting research (e.g., ''I have been free to choose my own research topics within this project'') and freedom in communicating research (e.g., ''I have felt constraints on discussing my research on this project with others''). [13] After two poorly performing items were discarded, scale scores were computed by summing the ratings for the items (see Appendix C). Subsequent analyses indicated the two ''climate for academic freedom'' subscales exhibited good reliability (freedom in conducting the research: seven items, Cronbach's alpha = 0.77; and freedom in communicating the research: six items, Cronbach's alpha = 0.87), adequate variance (standard deviation = 0.70–0.75 on a five-point scale) and modest sub-scales intercorrelations ($r = 0.37$). These measurements are used as outcome measurements under Objective 3.

7.2. Objective 2: To assess whether the source or form of research funding is associated with the structure or nature of a student's research experience

7.2.1. Faculty advisor

The first set of questions about the project was designed to determine relatively stable structural aspects of the student's research experience. For instance, respondents were asked to describe the characteristics of the faculty member with whom they worked most closely on their project. Results are displayed in Tables 1–3. The largest proportion of students reported that the faculty member with whom they worked most closely was a full professor (55.6%), followed by associate (26.7%), assistant (14.2%) and other (3.9%). The majority (70.7%) reports that the faculty member was tenured. Students were also asked if the faculty member with whom they worked most closely received industry support. Seventy-three percent said ''yes'' ($N =$

[12] Since several of the items in the scale dealt with relationships with the research sponsor, only data from the 423 students who had funded research were used in the scale development.

[13] Factors had to have an eigenvalue of at least 1 to be considered; items with a loading of 0.4 or greater were included in the factor.

Table 8
Duration of involvement with projects

	Sample mean	Mean by source			Mean by form		
		Industry	Government	No external sponsor	Single	Consortial	Unfunded
Number of semesters	4.23	4.20	4.65	3.61	3.62	4.06	4.43

412), 9% said ‘‘no’’ ($N = 53$), and 17% did not know ($N = 92$).

There were significant differences on these faculty descriptors across sources of funding. Students who worked on government funded research were more likely to report working with a full professor (65.4%) than were industry funded (51.8%) or no external sponsor (48.0%). Conversely, these students were least likely to report working with an assistant professor (8%, compared to 39% for industry funded and 21% for no external sponsor). The overall chi-square ($\chi^2(6) = 25.76$) was significant at $p < 0.01$.

Surprisingly, students working on industry funded research (77.8%) and those who worked on government funded research (74.2%), were both more likely to report that their major professor received research support from industry than those working on projects with no external funding (62.0%; $\chi^2(4) = 14.42$, $p < 0.01$).

Finally, although relatively rare, students whose work is funded by industry are more than twice as likely to have a member of their graduate committee who is employed full-time in industry (15.8%) as those whose work is funded by either government (7.0%) or with no external funding (6.5%; $\chi^2(2) = 9.40$, $p < 0.01$).

There were no differences by form on any of the faculty descriptors.

7.2.2. Student involvement

The next set of questions about the research project was designed to tap the students' own level of involvement in the project. Respondents were asked to indicate if the research project was their thesis or dissertation research. Results are reported in Table 4. For the vast majority of students (479 or 85.2%), the project was their thesis or dissertation research. While industry funded research (89.9%) was more likely than government or no external sponsor (81%; 82%) research to be the student's thesis or dissertation research, it failed to reach the more stringent level of statistical significance used in the study ($p < 0.01$).

There were significant differences across forms of funding. Students whose research was funded by a consortium (91.9%) were more likely than individuals whose research was a single-source (83.9%) or not funded (75.9%) to report that the project was their thesis or dissertation research ($\chi^2(2) = 9.26$, $p < 0.01$). Thus, consortial research appears to provide greater support for traditional academic research than does either single source or non-sponsored.

Students were asked to indicate which of the four potential ways of getting involved in the research project applied to them. As seen in Table 5, the largest proportion of students indicated that they chose the project from a number of options (43.5%). Another large group indicated that they were as-

Table 9
Perceived nature of the research

	Sample mean	Mean by source			Mean by form		
		Industry	Government	No external sponsor	Single	Consortial	Unfunded
Basic vs. applied	3.28	3.36	3.21	3.23	3.20	3.34	3.53
Narrow vs. broad	3.04	3.11	2.91	3.12	2.99	3.13	3.10
Long vs. short	2.51	2.47	2.43	2.72	2.42	2.51	2.93
Innovative vs. routine	2.17	2.11	2.24	2.17	2.18	2.16	2.14

Table 10
Publications and presentations

	Sample mean	Mean by source			Mean by form		
		Industry	Government	No external sponsor	Single	Consortial	Unfunded
Refereed journal	1.40	1.43	1.48	1.21	1.41	1.45	1.23
Technical reports	1.42	1.42	1.53	1.25	1.48	1.39	1.22
Presentations	1.55	1.57	1.63	1.37	1.57	1.58	1.34

signed to the project (20.7%). Presumably, these are students whose faculty advisor has a program of research on which the student is expected to work. Approximately 21% indicated that they had developed the project on their own.

Interestingly, there were no significant differences in the ways in which students got involved in their project across forms or sources of funding. This finding should be reassuring to those concerned about students being ''forced'' to work on their advisor's industry-funded projects.

7.2.3. Influence on research

The next set of variables was intended to describe the nature of interaction between students and their research sponsor and faculty advisor. For these variables, those students who reported that their research was ''not funded'' were excluded from the analysis, since there was no sponsor. The category ''no external sponsor'' therefore consists only of those students who reported funding by some ''other university funds'' ($N = 53$). Questions focused on the influence of the student, the faculty advisor, the sponsor and ''others'' (typically other committee members) on the research. Using a five-point scale (1 = no control, 5 = complete control), respondents rated the influence of each of these individuals or groups on the overall direction and emphases of the research, on the project research methods, and on the interpretation and evaluation of results. Table 6 displays these data. Across all three aspects of the research project, students perceive themselves to have the greatest influence, followed closely by their faculty advisor, with research sponsors generally having little control.

There were significant differences across source on one influence item: sponsor influence on overall directions and emphases ($F(2,403) = 5.27$, $p < 0.01$). Students whose research was funded by a university source reported significantly less influence of the sponsor than did those funded by industry or government. The difference between industry funded and government funded was not significant. There were no significant differences across form of funding.

Students were asked to indicate how many times per semester they discussed their research with the research sponsor. These results are displayed in Table 7. Of those who reported some external source of funding for their research ($N = 423$), the mean frequency of interactions was 2.42 times per semester (SD = 6.5; median = 1.00). Thus, the frequency of contact was relatively low. There were no significant differences across source or form.

Students also reported the duration of their involvement with the project (Table 8). The mean

Table 11
Career goals

	N (%) sample	*N* (column %) by source			*N* (column %) by form		
		Industry	Government	No external sponsor	Single	Consortial	Unfunded
Industry	319 (66.9)	141 (65.6)	103 (64.0)	75 (74.6)	188 (66.7)	85 (62.6)	46 (78.0)
University	138 (28.9)	67 (31.2)	48 (29.8)	23 (22.8)	82 (29.1)	45 (33.1)	11 (18.6)
Government	10 (2.1)	5 (2.3)	4 (2.5)	1 (1.0)	5 (1.8)	4 (2.9)	1 (1.7)
Other	10 (2.1)	2 (0.9)	6 (3.7)	2 (2.0)	7 (2.5)	2 (1.5)	1 (1.7)

Table 12
Climate for academic freedom

	Sample mean	Mean by source			Mean by form		
		Industry	Government	No external sponsor	Single	Consortial	Unfunded
Climate Talk	4.17	4.17	4.27	4.03	4.18	4.22	4.02
Climate Do	3.92	3.89	3.97	3.87	3.95	3.88	3.85

duration of involvement in the project was 4.34 semesters (SD = 2.7, median = 4.0). There were significant differences across sources of funding ($F(2,456) = 5.16$, $p < 0.01$), with students working on government funded research reporting significantly longer involvement (mean = 4.65) than those working on university-sponsored research (mean = 3.61): industry-funded students' length of involvement was not significantly different from either. One can argue that students whose work is not funded are most motivated to complete it quickly, while those with government funding have the least time pressure. There were no significant differences across form of funding.

7.2.4. Nature of the research

Students were asked to rate the research project in which they had been engaged on dimensions of basic vs. applied, narrow vs. broad, long vs. short term, and innovative vs. routine (see Table 9). Using a five-point semantic differential scale, students rated their research as slightly more applied than basic (mean = 3.29; applied = 5, basic = 1); about equal on the narrow (= 1) vs. broad (= 5) dimension (mean = 3.04); more long-term (= 1) than short-term (= 5) (mean = 2.47), and as more innovative (= 1) than routine (= 5) (mean = 2.16).

There were no significant differences on these variables by source of funding. There were significant differences across forms of funding for the long-term vs. short-term dimension ($F(2,455) = 6.39$, $p < 0.01$). Students whose research was not funded reported that the research was more short-term (mean = 2.95) than those whose research was funded by a consortium (2.53) or by a single source (2.41).

7.3. Objective 3: To assess whether the source or form of research funding is associated with various outcomes, including the perceived "climate for academic freedom"

The final research question examined the relationship between source and form of funding and three types of outcomes: scholarly productivity, career goals and perceived academic freedom.

Table 10 presents data on student publications and presentations. [14] Respondents reported an average of 1.40 referred journal publications, 1.42 technical reports and 1.55 presentations based on their project research.

There were differences across sources of funding for publications in refereed journals, technical reports, and presentations. Respondents who were working on government funded research (mean = 1.48) and those working on industry funded research (mean = 1.48) were more likely to report refereed publications than those whose research had no external sponsor (mean = 1.21). The same pattern was true for technical reports and presentations at meetings ($F(22,435) = 8.36$, $p < 0.0003$). In short, having external funding for the research is more likely to result in publications, regardless of whether the funding is from industry or government sources. A similar pattern held true for form; non-funded research resulted in fewer publications than either single or consortial.

Given the concern some observers have expressed about industry research dissuading students from

[14] There was not enough variance on patents and trade secrets to analyze these outcomes.

Table 13
Multiple regression analyses — outcomes. Stepwise regression (Alpha for inclusion = 0.05)

Source	Beta	R^2	R^2 change	F change	df
Dependent variable: freedom to discuss research					
Basic (1) vs. Applied (5)	−0.17	0.04	0.04	21.29	1,454
Citizenship (1 = Citizen, 2 = Not)	−0.18	0.07	0.03	17.79	1,453
Fac. tenured (1 = No, 2 = Yes)	0.21	0.08	0.01	13.22	1,452
Fac. rank (1 = Asst, 2 = Assoc., 3 = Full)	−0.20	0.10	0.02	4.89	1,451
Dependent variable: freedom to conduct research					
Basic (1) vs. Applied (5)	−0.23	0.07	0.07	33.41	1,454
Citizenship (1 = Citizen, 2 = Not)	−0.16	0.10	0.03	13.33	1,453
Innovative (1) vs. Routine (5)	−0.13	0.11	0.01	7.74	1,452
Funding — Defense (0 = No, 1 = Yes)	0.09	0.12	0.01	3.94	1,451
Dependent variable: total number of publications					
Number of semesters involved	0.29	0.09	0.09	45.89	1,454
Not funded (0 = No, 1 = Yes)	−0.12	0.10	0.01	6.56	1,453
Narrow (1) vs. Broad (5)	0.10	0.11	0.01	5.26	1,452

academic careers, students were asked to indicate where they expect to seek their first job after they receive their degree. Results are displayed in Table 11. Two-thirds of respondents (66.9%) report that they will seek their first job in industry after finishing their graduate work, while 28.9% will seek a university position. There were no differences across source or form of funding. Thus, contrary to concerns raised in the literature (Kenny, 1987), working on industry funded research does not appear to be related to a greater or lesser likelihood of pursuing a career in industry. However, this may be perceived as bad news by those who hope these initiatives stimulate interest in industrial careers.

Results related to perceived climate for academic freedom are displayed in Table 12. Higher scores indicate greater freedom (e.g., agreement that there are not constraints on research or communications). The mean for freedom in conducting the research is 3.93 (out of 5.0); the mean for freedom in communicating about the research is 4.19 (out of 5.0) Overall, students tend to perceive that they are not constrained in either of these areas. The lower mean and more restricted variance for freedom in conducting research may be partially explained by the fact that students, because they are students, may experience some lack of freedom in choosing how to conduct their research. The faculty member (generally the principal investigator on sponsored research) probably has final say over appropriate research methods. This interpretation is supported by the results reported above with respect to the influence of the faculty advisor.

Interestingly, there were no differences on either of the climate measures across source or forms of funding. Thus, this study provides no evidence that industry funding is related to students' perception of infringements on how they conducted their research or on the communications about the research findings.

8. Exploratory analyses

In order to more fully understand what influences the climate scales, variables from the domains of funding source, student descriptors, influence on research, faculty descriptors, interactions with the research sponsor and the nature of the research were examined as predictor variables. [15] Results are displayed in Table 13.

The most striking finding from these exploratory analyses is our predictions explain that very little

[15] Academic department and industry funding level were initially used as covariates. Since they did not have an impact on the results, we report regressions without these variables.

variance in out climate measures. We were able to explain 12% and 8% of the variance in ''freedom to conduct research'' and ''freedom to communicate'' scales, respectively. The two best predictors of both climate measures was working on more basic research and being a US citizen. Working on research perceived as more innovative was the final significant predictor of ''freedom to conduct research''. While working with a more senior professor was the final significant predictor of ''freedom to communicate research''.

Some preliminary exploratory analyses were conducted to examine the relationship of citizenship to other variables. One might ascribe differences in motivation to citizens and non-citizens. The career goals of these two groups were compared via chi-square analysis; the null hypothesis of independence could not be rejected. There was a significant relationship between citizenship and how students got involved in the major research project; non-citizens were more likely to have been assigned to the project. Non-citizens are less likely to be involved in research funded by a civilian government agency.

9. Discussion and conclusions

Before we discuss our findings, we want to acknowledge some limitations of the current study. Any field research study with finite resources will need to balance issues of validity against generalizability. In most of these cases, generalizability should take a back seat to validity (Cook and Campbell, 1979). Such is the case in the current study. Given the resources available for the study, we had to make choices about sampling institutions and disciplines. As a consequence, we deliberately focused our attention on engineering programs at the top 100 R&D institutions because we felt this discipline and these institutions have been under the most pressure to engage in cooperative research. While this may be true, it also means one should avoid generalizing these results to non-engineering disciplines and other institutions. While we have more confidence in the generalizability of our findings within engineering, the limited sample of departments used in our study should dictate caution. Finally, like any mail survey, we need to acknowledge the possibility of non-respondent bias. In fact, comparisons reveal that our sample includes a higher percentage of US citizens than are found at US graduate programs in science and engineering. While this discrepancy may affect generalizability, there appears to be no reason to believe it would bias our cross-source and cross-form comparisons.

9.1. Summary

Most of what we know about cooperative research is communicated at a very aggregate level. For instance, we know that almost 7% of all university R&D is sponsored by industry (National Science Board, 1996). However, this aggregate picture does not do a very good job of conveying the kind of environment large subgroups of students are experiencing. According to our data, graduate students in the engineering departments we surveyed are exposed to an environment where industry's presence and influence is ubiquitous. Nearly half of all students spent most of their time working on a project which was supported by industry. At the same time, almost three out of every four student surveyed reported that their faculty advisor received some support from industry. Interestingly, it is also worth noting the real outlier in this picture: only 20% of graduate students work on a project which has no external sponsor (not funded or university sponsored).

There are probably several reasons for the high rate of industry support. First, most industry support is now channelled through cooperative research centers where it gets leveraged and multiplied by government support. As a consequence, approximately 15% of all university support is estimated to come through industry–university centers (Cohen et al., 1994). Support from contracts and other industry funding push total industry support to between 20% and 25%. Finally, industry funding is more concentrated in the discipline and departments we studied. Thus, if we had any doubt that our engineering graduate students were being exposed to an environment which is ripe with industry's dollars and potential influence, our findings should put those doubts to rest. While this snapshot of industry presence is intriguing and to some, perhaps troubling, the more important question is what difference does the source and, relatedly, the form of sponsorship make on a student's research experience and the outcomes of that experience.

According to our findings, source of sponsorship and to a lesser degree form of sponsorship are, in fact, associated with a number of differences. However, our results also show that these differences tend to be minor and related to structural aspects of a student's research involvement, as opposed to what the student actually experiences and eventual outcomes. Further, the most striking differences observed were not between industry- and government-supported projects but between sponsored projects and projects with no external sponsor.

For instance, students working on government-sponsored projects are more likely to be supervised by a full and tenured professor. In contrast, students working on industry-sponsored projects are working with more junior faculty and are more likely to have an individual employed full time by industry sitting on their academic committee. We believe these findings probably reflect cohort differences: older more senior faculty established their research programs when federal support was readily available and have continued these ties; young faculty probably find more opportunities in the one growing segment of the university research portfolio — industrial support.

However, given the concerns raised in the literature, the lack of differences between industry and university-sponsored research appears to be more noteworthy than these minor differences. For instance, according to our findings, industry-supported projects are just as likely as government-sponsored projects: to be doing academic quality research (as evidenced by the project being their thesis); to involve a faculty member who receives some support from industry; and to involve students who choose, as opposed to being assigned to, that project. Interestingly, while sponsored research was by far the norm, students report infrequent interaction with their research sponsors (whether industry or government). Consistent with this finding, industry-supported students perceive themselves to have as much influence on their research projects and to be doing research that is similar in terms of basic/applied, long-term/short-term, etc., as their government-sponsored counterparts. Since students supported by these two sectors appear to be having similar research experiences, it should come as no surprise that they also report similar outcomes in terms of publications, career goals and perceived climate for academic freedom.

At the same time, our findings provide some support for authors who have argued that source of sponsorship will matter less than sponsorship itself. In fact, students engaged in research with no external sponsor (university funded, unfunded) report substantially different research experiences. Not only are they more likely to work under a very junior and untenured faculty member, that faculty member is less likely to receive any industry support. At the same time, these students are involved in their research for shorter time (compared to government), perceive their project to be more short term in its goals and produce fewer publications.

Form of sponsorship was only associated with a few differences: consortial support was more likely to involve a thesis than single-sourse or non-funded, and non-funded research was more likely to be viewed as short term. This seems consistent with findings in some of our earlier research (Gray et al., 1986).

Thus, while industry's presence is widespread our results offer little support for those who believe that presence is undermining the research experience students receive and/or eroding core values like academic freedom.

9.2. Discussion

The current study focused on a population which many believe is particularly susceptible to some of the unintended consequences discussed in the literature — graduate students. Graduate students have little power and therefore have less choice in what they do; they are also at an impressionable point in their career, which may help set future behaviors and values. Acknowledging that we were not able to address every untoward effect, there are a number of explanations for our findings of no differences.

First, the very vulnerability that seemed to make students a good subject for this study may also help explain our results. Most faculty and institutions carefully screen research projects for their appropriateness for student involvement. Thus, in spite of occasional stories of exploited students (e.g., Helwig, 1988), there is reason to believe that our highly professionalized faculty (Counelis, 1993) make sure that students only get heavily involved in sponsored research which is consistent with their educational mission. Under current circumstances, where faculty continue to have access to a wide array of funding options to support students (Schumacher, 1992) this is probably relatively easy to do.

Second, a number of authors have argued that it is probably naive to talk about complete academic freedom. Most research, particularly technical research, involves patrons and while the research may be value free, its use is not (Brooks, 1993). Viewed in this way, there is every reason to believe that much of the federal research performed on our campuses is just as likely to involve implicit or explicit constraints and to have the potential to lead to valuable intellectual property. Consistent with this view, the most significant differences we observed were between sponsored and unsponsored research, not between types of sponsors. Surprisingly, most of these differences favored sponsored research (e.g., more publications).

If source of support and form of support do not affect academic freedom and other outcomes and processes, what does? According to our exploratory analyses, engaging in research that is ''applied'' and being a foreign student explain a small but non-trivial amount of the variance. The former finding seems consistent with our earlier speculation that the kind of research in which one engages in, but not necessarily who sponsors it, has the potential to influence the perceived ability to freely conduct and communicate about the research. Evidence that foreign students report lower perceived climate for academic freedom was surprising. One explanation is that these differences simply represent cultural or communication differences (Barber et al., 1987). If true, this would be important to be considered in future research. Another explanation is that because foreign students are more likely to have their education underwritten by and be expected to return to an employing firm, they are more likely to feel constrained in their research choices and/or communications.

9.3. Policy implications and future research

The US and other countries (Brimble and Sripaipan, 1997) have invested considerable resources in encouraging cooperative research between their universities and firms. While most of the recent policy discussion about these investments have revolved around the extent to which these initiatives deliver their intended benefits, a variety of voices have cautioned that we must also weigh their potential costs, particularly regarding core institutional values like academic freedom. These issues are particularly acute when they may affect our next generation of professionals. Unfortunately, the empirical literature is virtually silent about these concerns.

While no single study, no matter how methodological rigorous, can settle such a complex and far reaching issue, our findings appear to provide some support for individuals who have argued that the burden-of-proof should be on those who believe that increased industrial support is inherently different from other kinds of funding and will distort or corrupt our educational institutions and their core values.

Perhaps more importantly, the current study has demonstrated the feasibility, and we hope the desirability, of empirically addressing these kinds of issues. There is no reason the ''benefits'' side of the cooperative research debate should be awash with data while the ''costs'' side is decided by polemics. In fact, most of the processes (e.g., how students became involved in projects) and outcomes (e.g., publications and career goals) examined in this study could be addressed in the typical cooperative research ''benefits'' study, if investigators took the time to consider the ''costs'' side of the equation. At the same time, we believe that creative use of well established constructs like organizational climate will allow investigators to examine some of the more abstract but important issues like academic freedom.

What kind of research questions should be addressed? First, although Blumenthal et al. (1997) report relatively stable effects between their 1984 and 1995 assessments, social processes change over time and, therefore, our findings should be updated. In addition, we believe that efforts to extend our research to faculty should be a high priority. As we have discussed, faculty are involved in a much more diverse array of cooperative research activities than students, including work with start-up companies, equity in new firms, etc. and may be subject to pressures students are shielded from. At the same time, this research should begin to move away from asking relatively simplistic questions like, ‘‘Does sponsorship affect research outcomes?’’ and begin asking more focused questions, like, ‘‘Under what conditions does sponsorship affect research outcomes?’’, ‘‘What are the proximate causes of publication delays?’’ For instance, Blumenthal et al. (1986a; b) report that conflicts of interest were more likely to be reported when the research was sponsored by a small firm. Similarly, Brooks (1993) encourages investigators to look past the crude labels of basic and applied and try to understand whether influence is internal or external, centralized or decentralized. While a more focused research agenda is needed, Slaughter (1988) has cautioned, real progress will also require a much more theoretically grounded understanding of issues like academic freedom.

In the final analysis, we share the optimistic viewpoint of Giamatti (1982) about our ability to balance the demands of science and relevancy: ‘‘We should negotiate appropriate arrangements, openly arrived at, that can further our mission. The constant challenge for the university is to know in clear and principled terms how to cherish learning, and its pursuit, for its own sake; and how to assist in bringing the results of free inquiry to the rest of the society for the good of the public’’ (p. 1280). However, in our view, continuing to meet this challenge will require us to commit to a program of policy research which rigorously examines the potential ‘‘costs’’ as well as ‘‘benefits’’ of cooperative research.

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Appendix A. Sponsorship aggregated by sponsor source

	N	Percentage
No external sponsor	101	20.95
Not funded	59	
Other university funds	42	
Industry	217	45.02
NSF I/UCRC	92	
Non-university based research consortium	45	
Single company	80	
Government	164	34.02
Civilian government agency	76	
Defense agency	88	

Appendix B. Sponsorship aggregated by form

	N	Percentage
Not funded	59	12.24
Consortial funding	137	28.42
NSF I/UCRC	92	
Non-university based consortium	45	
Single-source funding	286	59.34
Other university funds	42	
Single company	80	
Civilian government agency	76	
Defense agency	88	

Appendix C. Climate for academic freedom subscales

Freedom in conducting the research

I have been free to choose my own research topics within the project.

I think the research design is slanted to give results favorable to the project sponsor.

I have been free to choose the research tools/methods which I feel are appropriate for the project.

The sponsor insists on immediate results or the project won't get support.

I have been asked to write up results or otherwise interpret them in ways I do not agree with.

Indication that continued funding for this project depends on results favorable to the sponsor.

I have been asked to interpret results in the way favorable to the sponsor of the research.

Freedom in communicating about the research

I have felt constraints on discussing my research on this project with others.

There have been no constraints on the free exchange of ideas about this project among students in this department.

There have been no constraints on the free exchange of ideas about project — students in different departments.

There have been no constraints on the free exchange of ideas about project among faculty in this department.

There have been no constraints on the free exchange of ideas about project — faculty in different departments.

I have been able to consult freely with anyone I choose on my research.

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