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It is widely held that improved industry-university (I-U) cooperation can contribute to technological innovation and productivity in the United States. Although various federal programs have attempted to stimulate cooperation between these two sectors, most have escaped serious evaluative scrutiny. This study describes an exception to this trend: an empirical evaluation and comparison of two federally funded programs designed to foster cooperative science. Among other findings, results appear to indicate that participants in I-U Projects perceive applied objectives like patent development as the most important goal of their collaboration, whereas I-U Centers promote a more basic goal of knowledge expansion. Participants within each model exhibit high agreement on the goals of their collaboration. In addition, both programs appear to stimulate new research projects back in corporate laboratories.

INDUSTRY-UNIVERSITY PROJECTS AND CENTERS

An Empirical Comparison of Two Federally Funded Models of Cooperative Science

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Over the past two decades, interactions between universities and industry have expanded and relations between these two sectors have warmed. Reasons for this apparent rapprochement include the leveling off of federal research funding for universities, a pro-

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business atmosphere on campuses, and a growing appreciation by industry of the importance of science (and well-trained scientists and engineers) in the development of new products and processes (National Science Foundation, 1982). In spite of these developments, many still believe that the barriers to meaningful cooperation—cooperation that can contribute to technological innovation and corporate and national economic vitality—remain formidable (Solomon and Tornatzky, forthcoming). As a consequence, in spite of federal cutbacks in many areas, initiatives designed to foster cooperation between these two sectors continue to enjoy considerable support (Maugh, 1985).

FEDERAL INDUSTRY-UNIVERSITY INITIATIVES

The most prominent extant initiatives fostering industry-university cooperation are rooted in the Nixon administration's Experimental R&D Incentives Program, for example, the Industry-University Cooperative Research Centers Program (Colton, 1982), and subsequent Carter administration initiatives, such as Industry-University Cooperative Research Projects and the Small Business Innovation Research Program. Consistent with its noninterventionist market force ideology, the Reagan administration (Walsh, 1984) has promoted a number of indirect initiatives such as tax and other fiscal incentives designed to remove barriers to and promote a favorable climate for cooperation (National Science Foundation, 1982).

Regrettably, the available literature on industry-university cooperation has been dominated by case studies of existing arrangements or experience-based guidelines for successful cooperation and has failed to promote an empirical or critical analysis of exsiting arrangements. A recent review by Baldwin and Green (1984) indicated that only 4% of all publications on industry-university cooperation are empirical, with many of these being descriptive studies. The 1982 National Science Board report (National Science Foundation, 1982: 19) on industry-university relations concludes, "Only recently has there been a surge in

Foundation. However, any opinions, findings, and conclusions or recommendations expressed in this article are our own and do not necessarily represent the views of the National Science Foundation. We would like to thank the on-site evaluators who implemented the Centers Program evaluation and the university and industry participants in Projects and Centers who cooperated in our assessment efforts.

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the literature of [sic] the subject, but these contributions while welcome, generally lack historical depth, adequate field data or systematic coverage." Not surprisingly, given this trend, most federal initiatives in this area have escaped serious evaluative scrutiny. Two recently completed analyses of programs sponsored by the National Science Foundation (NSF) are exceptions in this "vast wasteland" of empirically based evaluation research on industry-university cooperative initiatives. Although these evaluations were conducted separately, their use of similar assessment strategies and some identical measures provide a unique opportunity for a comparative assessment of these two models of cooperative science.

TWO NSF MODELS FOR INDUSTRY-UNIVERSITY COOPERATION

Over the past decade, NSF has operated two programs designed to foster cooperative research between universities and industry: the University-Industry Cooperative Research Projects Program (Projects Program) and the University-Industry Cooperative Research Centers Program (Centers Program).

The Projects Program, begun in 1978, funds research in the physical and biological sciences and in engineering through a cost-sharing formula with industry. These time-limited research projects are performed jointly by university researchers and scientists from a single industrial firm typically working on a one-to-one basis.

The Centers Program, currently sponsored by the Directorate for Engineering,[1] was piloted on a small scale between 1972 and 1977 and initiated on a larger scale in 1978. The program provides funding, also cost-shared with industry, and technical assistance for the development of university-based research centers. These Centers consist of a university-based administrative core that supports and coordinates a series of interrelated research projects, each of which involves faculty, staff, and students from several academic departments. Industrial funding is provided by a consortium of industrial firms, or "sponsors," who pay an annual membership fee. Most Centers conduct research in engineering areas, although some do research in the physical and biological sciences.

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The Centers and Projects Programs were both designed to help create linkages between universities and industry and to foster fundamental science and more rapid technological innovation. The programs also share a number of structural and operational features: They involve NSF and industry cost-sharing of the research; they are typically university initiated; they involve a peer review of research by NSF; they involve cooperation between industry and university scientists; and they predominantly bring together the top R&D universities and *Fortune* 500 firms. In many other respects, however, these programs are quite dissimilar.

As illustrated in Figure 1, two strikingly different mechanisms of linkage are at the heart of these two programs. Projects generally consist of a simple collaboration between individual scientists within a university and a single company, not unlike traditional consulting or contract arrangements. In some cases, a more complex collaboration might occur between several university scientists and several scientists in a single company. Regardless, interactions in Projects generally remain personal scientist-to-scientist exchanges driven by a research collaboration. In contrast, the typical or simple Center cooperative arrangement involves a collaboration between a team of university scientists (from two or more departments) with representatives from several member companies, all within the context of a new university-based organization, the Center. In the complex example portrayed in Figure 1 (which now exists in several operating Centers), scientists from several departments at two or more universities conduct research that is sponsored by several companies. Although Centers obviously depend on personal scientist-to-scientist linkages, these linkages tend to be structured and routinized by the Center's procedures and occur at periodic review meetings.

Another fundamental difference between these two programs is the intended duration of the cooperative arrangement. The Projects Program is designed to produce a time-limited, typically two-year, collaboration between university and industry scientists on a specific research project. In contrast, the Centers Program attempts to create a permanent organization for ongoing collaboration between university scientists and a consortium of companies. To this end, NSF provides a one-year planning grant, and a five-year operational grant (annual NSF funding gradually declines during that period) with the expectation that industrial members will provide sustaining support for a Center. (As of

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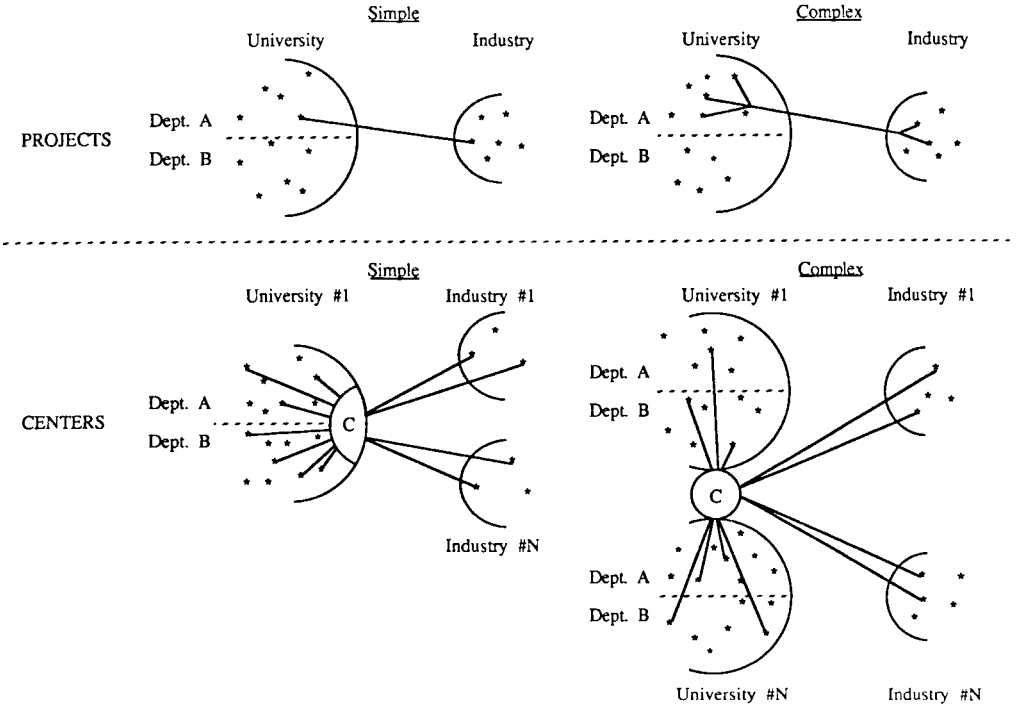

NOTE: * = individual scientists; C = Center; — = scientific and other exchanges.

Figure 1: Interaction Between Industry and University in Typical Projects and Centers

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1985, five Centers had become self-sufficient and no longer received NSF funds.) The other differences dictated by these discrepant approaches to cooperative science are summarized in Table 1. The implications of these features for program process and outcome is the focus of the current study.

METHODOLOGY

The Productivity Improvement Research (PIR) Section of ISTI was responsible for evaluating the Projects and Centers Programs for a number of years.[2] The goal of these separate and multifaceted evaluation efforts was to document and describe salient program structures, processes, and outcomes; to explore the relationship of variables within and between these domains; and, it is hoped, to discover features that contribute to successful outcomes for both the Projects Program and the Centers Program. The results of individual components of these evaluations are available in a number of reports (Johnson and Tornatzky, 1984; Johnson et al., 1984; Eveland et al., 1984; Eveland, 1985; Gray and Gidley, 1986). Although these evaluation efforts differed in many respects, both used survey methodology. Further, the surveys administered to industry and university participants of Projects and Centers were designed with a number of identical items and scales. Data from these two surveys, both collected in 1982-1983, are the basis for this study.

PROCEDURES

SAMPLE

For the Projects Program assessment, NSF/PIR staff sent surveys to industry and university principal investigators of 118 completed Projects. In all, 226 questionnaires were returned, a 96% response rate. The majority of Projects had terminated their grant activities, in some cases up to two years prior to the assessment.

For the Center's assessment, on-site evaluators at eight operating Centers sent surveys to participating faculty (principal investigator and

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TABLE 1
Projects Versus Centers

Dimension	*Projects*	*Centers*
Goal	Time-limited collaboration between scientists	Creation of a permanent organization for ongoing collaboration between scientists in a university and a consortium of companies
Funding		
NSF funding source	Shared: directorate plus projects program	Centers Program
NSF funding period	$\bar{x}$ = 24 months range = 12-48 months	1-year planning 5-year operating
Industry funding	Dependent on size of company; NSF may pay larger percentage for small companies	Determined by Center; an annual membership fee per company; 100% of Center budget after 5 years
Participants		
University	One or two scientists, typically from a single department	6-15 scientists, typically from several departments
Industry	One or two scientists from a single company	A board member (policy role and monitor (scientist) from several (6-25) companies
Processes		
Linkage mechanism	Scientist-to-scientist	Mediated via a new organization
Interaction	Research collaboration at either or both sites; meetings as necessary	Periodic structured review meetings (and other contacts on request)
Cooperative mode	Scientific collaboration	Industrial sponsorship and review of university-based research

other faculty conducting Center-sponsored research) and to the primary representative of each member company. Questionnaires were returned by 65 faculty and 133 industry representatives.[3] This represents at least a 90% response rate from both faculty and industry participants. Half of the Centers had been in operation for one year when surveyed; the remainder had been in operation from two to four years.

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INSTRUMENTS

Faculty and industry questionnaires were created for both studies based on the relevant literature and logical/practical consideration that appeared relevant to each model. Measures examined in this study were used in the evaluation of both Centers and Projects (for at least one respondent group).

Participant characteristics. These variables focused on personal characteristics of industrial participants (including seniority in their field, with their organization, or in the R&D area), levels to the C.E.O., and education.

Prior relationships. These variables were concerned with the history of interaction between participants, including frequency of personal contact between industry and university participants prior to this collaboration.

Perceptions of goal importance and likelihood of expected benefits. These variables examined the perceptions of industry and university participants on the importance of specific goals and the likelihood of specific benefits from their collaboration.

Outcomes. Participants were asked to report on results of their cooperation, the extent to which their collaboration stimulated new research projects in firm laboratories, and their satisfaction with specific aspects of their collaboration.

RESULTS

PARTICIPANT CHARACTERISTICS AND PRIOR RELATIONSHIPS

As Table 2 reveals, industry and university participants in Centers and Projects differ significantly on a number of personal descriptors. Although all industrial participants tend to be senior level and have considerable professional tenure, Center participants have significantly longer mean tenure in industry (22 versus 16 years) and in their current

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TABLE 2
Respondent Characteristics and Prior Contact

	Projects–Industry (N = 112)	*Centers–Industry (N = 133)*
Characteristics	$\bar{X}$	$\bar{X}$
Number of years employed in industry[b]	16.24	22.51
Number of years with current organization[c]	13.59	16.17
Years worked in R&D–in industry[a]	14.90	14.70
Years worked in R&D–current organization[a]	13.12	11.49
Number of levels to chief executive officer[a]	4.15	3.55
Education[d]		
BA/BS or less	9 (8.0%)	44 (34.6%)
MA/MS	13 (11.6%)	34 (26.8%)
Ph.D.	90 (80.4%)	48 (37.8%)
Prior Contact		
Prior contact with individuals from collaborating team[e]		
Several times per year	79 (70.5%)	57 (44.2%)
Rarely or never	33 (29.5%)	72 (55.8%)

a. Nonsignificant difference.
b. $t = 5.45$, $p \leq .001$.
c. $t = 2.62$, $p \leq .01$.
d. x^2 (2) = 44.48, $p \leq .001$.
e. x^2 (1) = 14.34, $p \leq .001$.

organization (16 versus 13 years) than their Project counterparts. Projects participants, in contrast, are significantly more likely to possess a Ph.D. than are Center participants. In spite of these differences, there are no differences between participants on years in R&D (in industry or in current organization) and levels to C.E.O.

Projects and Centers are also significantly different on the extent to which industry and university participants have had personal contact prior to the initiation of their Project or Center collaboration. A total of 30% of industry respondents (Rs) from Projects and the majority (56%) of industry Rs from Centers report that they rarely or never had prior contact with individuals on the university team.

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Thus, it appears that in the majority of instances Project linkages are continuations of preexisting professional relations, although about 30% are relatively new collaborations. In contrast, the majority of all Center companies are first-time collaborators with the university research team. Undoubtedly, some of the companies who reported prior contact with the Center research team are initiating a first-time collaboration with at least some members of that team.

PERCEPTIONS OF GOAL IMPORTANCE

Project and Center participants (both industry and university) were asked to rate the relative importance (4 = extremely important, 3 = considerably important, 2 = somewhat important, 1 = not at all important) of a series of goals/outcomes of their respective collaboration. These rankings are the most striking comparison between the two models of industry-university cooperation.

As Table 3 reveals, within Projects and within Centers there is a great deal of congruence between industry and university goal ratings. Within Projects, mean importance ratings given by the two respondent groups resulted in only one significant difference and identical goal rankings. Within Centers, two goals were given different mean importance ratings and there are some minor reversals in goal ranks. Overall, however, Center participants appear to be in virtual agreement on the importance of these goals.

In contrast, comparisons across Centers and Projects reveal that university and industry participants give significantly different ratings of goal importance, resulting in an almost complete reversal of priorities. For instance, whereas "expansion of knowledge" is ranked highest by Center Rs ($\bar{x}$ = 3.66 for university, 3.60 for industry), it is ranked lowest by Project Rs ($\bar{x}$ = 1.24 for university, 1.46 for industry). The "development of patentable projects" is ranked highest by Project Rs (x = 3.43 for university, 3.67 for industry) and sixth and seventh by Center Rs ($\bar{x}$ = 2.12 for university, 1.93 for industry). Most differences between Centers and Projects were significant at or below $p < .001$.

EXPECTED BENEFITS

Industry Rs in both Projects and Centers were asked to rate the likelihood (4 = almost certain, 3 = pretty likely, 2 = somewhat likely, 1 =

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TABLE 3
Comparison of Goals/Potential Outcomes

	Projects				*Centers*			
	University		*Industry*		*University*		*Industry*	
Goal/Outcome	*Rank*	*Mean*	*Rank*	*Mean*	*Rank*	*Mean*	*Rank*	*Mean*
Patentable products[a,b]	1	3.43	1	3.57	6	2.12	7	1.93
Commercialized products[a,b]	2	3.26	2	3.31	7	1.86	6	2.14
Redirection of university research[b] toward industrial problems	3	2.58	3	2.54	4	2.66	3.5	3.02[e]
Enhanced research in industry[a,b]	4	2.43	4	2.28	3	2.92	2	3.10
Enhanced student understanding of industry[b,c]	5	2.35	5	2.27	5	2.64	3.5	3.02[e]
Enhanced student technical training[a,b]	6	1.57	6	2.02[d]	2	3.37	5	2.98[f]
General expansion of knowledge[a,b]	7	1.24	7	1.46	1	3.66	1	3.60

NOTE: All tests are t-tests.
a. Between Projects and Centers, university was significant at $p \leq .001$.
b. Between Projects and Centers, industry was significant at $p \leq .001$.
c. Between Projects and Centers, university was significant at $p \leq .05$.
d. Within Projects, university versus industry was significant at $p \leq .01$.
e. Within Centers, university versus industry was significant at $p \leq .01$.
f. Within Centers, university versus industry was significant at $p \leq .001$.

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scarcely likely) of realizing certain benefits from their collaboration. It is interesting to note that industry Rs from both Projects and Centers hold similar expectations of the likelihood of the benefits under consideration. Both Project and Center Rs indicate that "better personnel recruitment" (x = 2.46 for Projects, 2.54 for Centers) and "improved research projects in your lab" (x = 2.59 for Projects, 2.60 for Centers) are between "pretty likely" to "somewhat likely" to be realized. In contrast, both groups report that "patentable products" (x = 1.58 for Projects, 1.62 for Centers) and "commercialized products" (x = 1.69 for Projects, 1.75 for Centers) are between "somewhat likely" to "scarcely likely" to be realized.

In the context of the previously reported goal importance ratings, these findings reveal an apparent inconsistency for Project Rs. Whereas Center participants from industry perceive patentable and commercializable products as neither important goals nor expected benefits, Project participants see these objectives as important goals but *not* as likely outcomes of their collaboration.

SATISFACTION

All Project and Center Rs were asked to indicate their satisfaction (4 = completely satisfied, 3 = considerably satisfied, 2 = some satisfaction, 1 = not at all satisfied) with the technical quality, communication, and the administration of their collaboration as well as their general satisfaction (industry Rs only). In absolute terms, all respondents report fairly high levels of satisfaction. As Table 4 indicates, participants within a program exhibit similar levels of satisfaction. Participants in Projects report almost identical satisfaction. The only significant difference between university and industry participants in Centers is on communication; industry reports higher satisfaction in this domain. Across Centers and Projects, university participants in Projects reported significantly higher satisfaction with all aspects of their collaboration (technical quality, communications, and administration) than their Center counterparts. Industry participants in Projects reported significantly higher satisfaction on technical quality and general satisfaction than their Center counterparts.

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TABLE 4
Satisfaction with Collaboration

	Projects		*Centers*	
	University	*Industry*	*University*	*Industry*
Satisfaction with				
Technical quality of research[a,c]	3.57	3.47	2.81	2.97
Communications[a]	3.14	3.20	2.51	2.99[e]
Administration[a]	3.24	3.09	2.72	3.07[d]
General satisfaction[a,b]		3.15		2.89

NOTE: All tests are t-tests. Within Projects there were no significant differences. 4 = completely satisfied, 3 = considerably satisfied, 2 = somewhat satisfied, 1 = not at all satisfied.
a. Between Projects and Centers, university was significant at $p \leq .001$.
b. Between Projects and Centers, industry was significant at $p \leq .01$.
c. Between Projects and Centers, industry was significant at $p \leq .001$.
d. Within Centers, university versus industry was significant at $p \leq .001$.
e. Within Centers, university versus industry was significant at $p \leq .001$.

STIMULATION OF NEW INDUSTRIAL RESEARCH PROJECTS

Differences between the Projects and Centers Programs in total amount of funding support, number of projects and person years of research, and number of years elapsed since the research was conducted makes impossible a direct comparison of new research stimulated in companies. However, reports of new research projects by industrial participants are an important sign of technology transfer and warrant mention.

Collectively in the Projects Program, companies reported that this research resulted in the initiation of a total of 91 new research projects in their own labs worth an estimated $9 million (average new project = $98K). Companies participating in Centers reported starting 68 new projects worth approximately $4 million (average new project = $61K). These reports indicate that considerable technology transfer from university to industry is resulting from both programs.

DISCUSSION

Industry-university cooperation has become an important area for public policy and possible federal intervention (Rosenzweig and

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Turlington, 1982). Regrettably, most government initiatives in this area have escaped serious evaluative scrutiny or have been examined based on grateful testimonials and/or impressionistic case studies. The current study and the evaluations upon which it is based represent a unique attempt at an empirical analysis and comparison of two federal programs designed to foster cooperation based on feedback from industry and university collaborators.

However, post hoc field evaluations like this one, which was based on the fortuitous comparison of two models of industry-university cooperation on variables derived from parallel but separate survey-based evaluation efforts, are subject to their own shortcomings. Thus, some of these problems should be acknowledged.

These findings are based on self-report data that were directly or indirectly collected by the sponsoring agency, the NSF; thus, they are subject to all the demand characteristics and tendencies to "please the investigator/sponsor" that one finds in more traditional laboratory research (Silverman, 1974). In addition, the procedures followed in the two evaluation studies differed in a number of respects (for instance, local evaluators known to virtually all respondents carried out the Centers Program evaluation while an unknown NSF staff person carried out the Project Program evaluation). Regrettably, one cannot rule out the possibility that such procedural differences might influence and bias these findings (Fairweather and Tornatzky, 1979). As in any evaluation where such flaws exist, the reader should be cautious in drawing conclusions based solely on these findings.

In spite of these methodological problems, these findings present an intriguing and to a large extent favorable picture of both the Projects Program and the Centers Program. Although relative satisfaction differences favor the Projects Program, the absolute level of satisfaction expressed by participants in both programs is surprisingly high. On a more concrete level, the direct investments of firms in Projects and Centers plus reports of additional investments in new research totaling $9 million for the Projects Program and $4 million for the Centers Program represent another strong endorsement of both programs. Although there is no way of determining to what extent these are actual increments in R&D investments or simply redirected R&D dollars, these reports are solid evidence that knowledge/technology transfer from universities to industry is occurring through both Projects and Centers.

Our findings highlight some interesting participant and process differences between the two models. Regrettably, our data did not allow

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us to compare faculty who participate in Projects and Centers. However, our findings suggest that somewhat different elements of the industrial R&D community are being drawn into these cooperative models. For example, industrial participants in Projects are predominantly individuals with Ph.D.s who have spent all their careers in R&D whereas industrial participants in Centers tend to be longer-tenure, non-Ph.D. managers who have spent some of their career in another area. These differences seem fairly consistent with the different role demands of the two programs (industrial participants in the Projects generally function as coprincipal investigators on a single project; industrial participants in Centers generally fulfill a policymaking function by overseeing several projects). In addition, whereas the Projects model seems best suited to forging alliances between faculty and firms that have worked with each other in the past, the Centers model seems somewhat better suited to creating research linkages between faculty and firms who have never collaborated before.

The two programs also appear to forge alliances oriented toward substantially different goals. Project participants whose collaboration is one-on-one and usually short term, perceive their model to be oriented toward very concrete and short-term development goals. Centers, which involve multiple sponsors (and therefore little opportunity to derive a proprietary edge) and a long-term collaboration, are perceived by participants to be oriented toward more general and downstream goals of knowledge expansion and training enhancement. Although the contrast between these goals is striking, it is probably more noteworthy that both programs produced a tremendous amount of goal congruence between industry and university participants within each model. Since progress in both applied and basic research will be needed to accelerate technological innovation in the United States, these programs can be seen as complementary.

These findings are not without some apparent disappointments and contradictions. Surprisingly, industrial participants in Projects indicate that development of patentable and commercializable products is their most important goal; however, they also indicate that they do not think it is a very likely outcome of their collaboration. This may indicate a realization that patents and commercializable products are downstream goals that will be realized much later, when development work has been completed in their industrial labs.

Although speculative, we believe these findings might provide policymakers a basis for engineering "hybrid" models of cooperation having some of the attributes of both Centers or Projects. One might be

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able to engineer a "Multi-Company Project" model that would theoretically be oriented more toward "general knowledge production" objectives. Similarly, one could attempt to leverage the Center model toward more downstream development by cost-sharing a specific project (initiated within a Center) through a project grant with a single company. In fact, the latter scenario appears to be occurring spontaneously at Centers without any federal involvement.

CONCLUSIONS

In spite of recent federal budget cutbacks, cooperative scientific initiatives have become a growth industry in the United States. Municipalities and even individual universities have begun to develop and fund cooperative scientific ventures (that is, research parks, research centers or institutes, small business incubators, and so on) as part of an "innovation driven strategy" for economic development (Gray et al., forthcoming). Although the precise amount of money being invested in these ventures is unknown, conservative estimates would be that well over a billion dollars have been spent on these efforts in the last several years. Regrettably, since few of these scientific/technological reforms are being subjected to evaluative scrutiny, it is currently impossible to say which models work best in what circumstances or how much of the public money going into these initiatives is being spent wisely. Although the current study is not without its methodological flaws, we believe it demonstrates the feasibility and, it is hoped, the desirability of empirically evaluating these promising but very expensive public initiatives.

NOTES

1. In 1985 administration of the Centers Program was transferred from NSF's Division of Industrial Science and Technological Innovation (ISTI) of the Directorate for Scientific Technological and International Affairs to the Directorate for Engineering.

2. The Productivity Improvement Research Section (PIR) within ISTI no longer exists. Funding for the section was eliminated within NSF in 1985.

3. Twenty companies appointed more than one individual to fill the board member role. Thus, most data reported include multiple respondents for these companies. However, reports of total dollars, personnel, and projects are unduplicated; multiple responses for a company were averaged.

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REFERENCES

BALDWIN, D. R. and J. W. and GREEN (1984) "University-industry relations: a review of the literature." Society of Research Administration J. XV: 5-17.

COLTON, R. M. [ed.] (1982) Analyses of Five NSF Experiments to Stimulate Increased Technological Innovation in the Private Sector. Washington, DC: National Science Foundation.

EVELAND, J. D. (1985) Communication Networks in University-Industry Cooperative Research Centers. Washington, DC: National Science Foundation, Productivity Improvement Research Section.

———W. HETZNER, and L. TORNATZKY (1984) Development of University-Industry Cooperative Research Centers: Historical Profiles. Washington, DC: National Science Foundation, Productivity Improvement Research Section.

FAIRWEATHER, G. W. and L. G. TORNATZKY (1979) Experimental Methods for Social Policy Research. New York: Pergamon.

GRAY, D. and T. GIDLEY (1986) An Assessment of the University-Industry Cooperative Research Centers Program. Unpublished report, Department of Psychology, North Carolina State University, Raleigh.

GRAY, D., T. SOLOMON, and W. HETZNER [eds.] (forthcoming) Technological Innovation: Strategies for a New Partnership. Amsterdam: Elsevier North-Holland.

JOHNSON, E. and L. G. TORNATZKY (1984) Cooperative Science: A National Study of University and Industry Researchers. An Assessment of the IUCR Projects Program. Washington, DC: National Science Foundation, Productivity Improvement Research Section.

———and L. R. SCHLAAF (1984) Cooperative Science: A National Study of University and Industry Researchers. Washington, DC: National Science Foundation, Productivity Improvement Research Section.

MAUGH, T. H. (1985) "Technology centers unite industry and academia." High Technology 5: 48-52.

National Science Foundation (1982) University-Industry Research Relationships: Myths, Realities, and Potentials. Washington, DC: Government Printing Office.

ROSENZWEIG, R. M. and B. TURLINGTON (1982) "Industry-university collaboration: the new partnership," in The Research Universities and Their Patrons. Berkeley: Univ. of California Press.

SILVERMAN, I. (1974) "The experimenter: a (still) neglected stimulus object." Canadian Psychologist 15: 258-270.

SOLOMON, T. and L. G. TORNATZKY (forthcoming) "Rethinking the federal government's role in technological innovation," pp. 41-58 in D. Gray et al. (eds.) Technological Innovation: Strategies for a New Partnership. Amsterdam: Elsevier North-Holland.

WALSH, J. (1984) "Skirmish on the industrial policy front." Science 224: 1410-1411.

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