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ABSTRACT

This report presents results of a survey of participants in the National Science Foundation (NSF) Industry-University Cooperative Research Centers program. The program promotes more rapid technological innovation by creating linkages between industry and university scientists. The Centers function as university research groups, with partial funding, policy guidance, and project monitoring carried out by a group of industrial firms. Data from 133 industry and 65 faculty participants are analyzed and categorized into five variable domains: descriptors, prior contact/center initiation, current operations, goals, and outcomes. Results indicate that: (1) Centers are built on new, rather than pre-existing relationships and represent a shift away from predominantly consulting relationships; (2) Centers are operated using a shared influence model; (3) faculty and industry are in agreement about the most important goal (expansion of knowledge) but differ on relative importance of some intermediate goals; and (4) both industry and faculty respondents are generally quite satisfied with the Centers. The study concludes that, while the Centers do not appear to have resulted in radical changes in the structure or methodology of academic or industrial science, they do appear to function as effective technology transfer vehicles for industrially relevant fundamental research. Appendices include questionnaires, a description of variables used in the study, and results of data reduction. (JDD)

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The work reported herein is the result of the efforts of several groups of people.

First, the on-site evaluators at each of the Centers collected the data. R. Christopher Knight (University of Massachusetts), Timothy Brock and George Smith (Ohio State University), Richard Perloff (Cleveland State University -- evaluator for the Center at Case Western Reserve University), Alok Chakrabarti (Drexel Institute of Technology for the Center at Rennsalaer Polytechnic Institute), George Walters (Rutgers University), Frank Budnick and Richard Mojena (University of Rhode Island), and John Kaatz (Georgia Institute of Technology) were responsible for the collection of the data analyzed in this report. (The senior author collected the data at North Carolina State University.)

Louis G. Tornatzky, William A. Hetzner and J.D. Eveland who until recently were with the Productivity Improvement Research Section at the National Science Foundation prepared the questionnaires, were primarily responsible for conceptualizing the overall evaluation of the Centers. They also managed the data collection, coded the data, and helped design the analysis strategy for this study.

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## EXECUTIVE SUMMARY

Survey data from 133 industry and 65 faculty participants in the first eight Industry/University Cooperative Research Centers have been analyzed. The 133 industry respondents were predominantly industrial advisory board members from 106 member companies. (Data from some monitors with these companies is also included.) Data from both industry and faculty respondents were categorized into five variable domains: descriptors, prior contact/center initiation, current operations, goals, and outcomes. Descriptive analyses were performed within these categories. Following data reduction, the descriptor, prior contact, current operations and goal variables were correlated with the outcome variables.

## DESCRIPTIVE RESULTS

### Respondent Descriptors

On the average, industry respondents had long tenure both in industry in general (mean=22.5 yrs.) and in R&D in particular (mean=14.7 yrs.). They tended to be relatively highly placed within their companies (mean=3.5 levels from CEO). The most noteworthy finding was the great variability around these averages.

The greatest proportion of faculty respondents were tenured faculty members; the largest proportion were at the rank of associate professor or above. Thus, it appears that Center participants from both industry and university were senior level managers and scientists, although there were significant numbers of less senior people in both sectors.

### Prior Contact/Center Initiation

Most participants in Centers had fairly infrequent or no prior contact with participants from the other sector. Over 55% of industry respondents reported they rarely or never had contact with Center personnel prior to the initiation of the Center; most reported little involvement in center initiation activities. The majority of the prior contact between industry representatives and faculty members was in the form of consulting arrangements. Thus, Centers are built on new, rather than pre-existing relationships and represent a shift away from predominantly consulting relationships.

## Current Operations

On the average, two to three functional groups at member companies worked directly with Centers. Thus, participation in Centers tended to span corporate divisional boundaries. R&D (Central and Divisional) and engineering typically were the groups which worked with the Centers. This suggests that the interaction between university and industry is focused on the scientific work of the Centers. Industrial advisory board members, technical monitors, and top management tended not to be involved in the day-to-day administration of the Centers. In contrast, faculty members were heavily involved in Center activities. On the average, faculty members were involved in 1.69 projects and spend 25% (median) of their time on Center research.

## Current Operations: Influence

Faculty evaluated the influence of various groups on several aspects of Center operations. The results suggest a shared influence model of Center operations. Faculty saw themselves as the most influential group in the actual conduct of the research; students were also seen as influential in this area. Faculty and the Center directors were rated about equal in their influence on project selection. Center directors were rated as the most influential in planning and strategy, budget and logistics, and appointments of faculty and staff. Industrial advisory board members were seen as being the most influential in evaluation of the research. University administration and university procedures were seen as having relatively little influence in any of the six areas.

## Goals

Faculty and industry were in virtual agreement about the most important goal (expansion of knowledge) and the least important goals (development of new research projects in firms, patentable products and commercialized products) of their Centers, but differed somewhat on the relative importance of some intermediate goals. Enhancement of graduate students' understanding of industry and redirection of university research toward industrial problems were rated higher by industry respondents, while faculty gave a higher priority to enhancement of graduate students' technical training. Overall, there was remarkable congruence between faculty and industry participants on the goals for their Center. The different ratings for the middle-ranking goals seem to reflect the different missions of industry and university.

## Outcomes: Expected Benefits

Industry and faculty respondents were asked to rate the likelihood of different sets of benefits; hence, direct comparisons are not possible. For the industry respondents, the indirect benefits of improved research projects and better personnel recruitment were seen as the most likely. About half of industry respondents saw patentable or commercialized products as scarcely likely benefits to Center participation. Faculty respondents also saw the indirect benefits as being the most likely (improved knowledge base), but also anticipated some more concrete benefits from the Center, particularly better student placement and recruitment and increased funding from private sources.

## Outcomes: Changes in Science

A minority of industry respondents report some changes in the structure and methods of R&D at their firms as a result of Center participation. The area where there was the most change was in research topics and issues. Many more faculty respondents reported that Center research was different from their usual research. Approximately 67% indicated that there was "some" difference in the criteria used to evaluate their research; 64% indicated there was "some" difference in their research topics and 40% indicated there was "some" difference in their research methods. Not surprisingly, Centers appear to be having a greater impact on the research topics and methodology of participating faculty.

## Outcomes: New Research

A total of 68 new in-house research projects (mean=8.5 per Center or .72 per company) were reported. These projects represent 4.13 million dollars (mean=$516.56 K per Center or $46.43 K per company).

In additionto the in-house research, 18.4% of companies reported new outside research contracts. These contracts totalled $906 K (mean=$113.25 per Center or $60.4 K per company).

Although there is no way to determine if this $5.04 million investment (research and contracts) involves new or reallocated research dollars, these projects confirm the changes in research topics and issues reported above and may be the most tangible sign that technology transfer between university and industry is occurring.

## Outcomes: Product and Process

In general, industry respondents reported few product or process outcomes (ie. new products, reduction in production costs, etc.) in their companies. Of ten proposed outcomes, only improved ability to cooperate with outside scientists was a realized outcome for a significant number of companies (30%).

Faculty appear to concur with industry on the modest impact Center participation had produced on corporate products and

processes, although they tended to overestimate slightly the outcomes realized by industry across the board. Notwithstanding these findings, product and process outcomes should be monitored as this relatively young cohort of Centers matures.

Outcomes: Personnel Exchange

A total of 179 students (mean=22 per Center) were interviewed for employment by member companies. Of these, 27 (mean=3 per Center) were hired. Without knowing the overall hiring rates for these companies, it cannot be determined whether Center participation increases a student's likelihood of being hired by a member company, from either the student's or the company's perspective.

A total of 80 university scientists spent time working on-site in company labs (mean=10 per Center). About half this number (39) of industry scientists spent time working in university labs (mean=5 per Center).

Outcomes: Career

Almost half of the faculty respondents (48.1%) reported that participation in their Center contributes a moderate amount to consideration for tenure, promotion or salary increases. Discussions with university officials indicate that research and publications rather than Center participation *per se* will contribute to faculty career advancement.

Outcomes: Evaluation

Both industry and faculty respondents were generally quite satisfied with the Centers. Faculty respondents were somewhat, but not significantly, less satisfied with the technical quality of the research and with responsiveness of the Center to industry needs than were industry respondents. They were significantly less satisfied with communications between Center staff and industry and with Center administrative practices. These differences in satisfaction may be a function of the different levels of involvement of these two groups in the Centers. While worth monitoring, these differences are probably not serious given the overall high levels of satisfaction.

While most industry respondents saw the Center research programs as being above average, few rated the research in the top 2%. Apparently, for most companies it is not essential that a Center be "in a league by itself"; however, the university probably must be perceived as having a top 10% or better than average research program.

DATA REDUCTION AND CORRELATIONAL ANALYSES

Data reduction via factor analysis was conducted to reduce the size of the large original data set. Correlational analyses were performed on the resulting variables and composites. These analyses suggest some interesting patterns of relationships

within variable categories and between structure/process variables and the outcome variables.

Correlations Within Variable Groupings

Respondent Descriptors The correlations of variables and composites within the respondent descriptors grouping were unremarkable.

Prior Relationships/Center Initiation Correlations examined after the data reduction indicated that those who had been students at the Center university tended to be more involved with the university in terms of various types of prior contact, including Center planning. These findings suggest that in the early stages of Center planning, pre-existing relationships may be tapped to provide assistance and support.

Correlations also revealed that in firms where a greater number of people had to concur in the membership decision, more levels within the company also had to approve. In these instances, the initiative to join the Center may have come from a lower level to begin with, or perhaps the organization was simply more bureaucratic in its decision-making. In either case, directors may want to monitor firm decision making since membership commitments from firms which require concurrence from multiple people at multiple levels may be more time-consuming and difficult to secure.

Goals Data reduction resulted in slightly different configurations of goals for faculty and industry respondents. For faculty, all goals belonged to one of two positively correlated factors which were labeled training and technical goals. For industry, the same factor structure resulted with two exceptions: general knowledge expansion was no longer part of the training factor and redirection of university research was not part of the technical factor. More importantly, the technical and training factors were not positively correlated. Thus, industry respondents appear to compartmentalize goals more than faculty and do not see the importance attached to technical and training goals as correlated.

Current Operations Correlations observed within this variable grouping suggested that three different profiles of Center-corporate interactions tended to occur. First, there was no relationship between interactions between Central R&D and a Center and other industrial groups and a Center (except a negative correlation with engineering/technical group involvement). This pattern suggests a very basic research involvement. Second, regular Divisional R&D involvement tended to be related to regular Engineering/Technical involvement, which in turn tended to be related to regular involvement of production groups. This set of relationships seems to mirror the flow of the R&D process from research to development to production. Finally, if top management was involved regularly in a Center, then it was more likely that corporate planning and marketing were involved, suggesting the final stages of product

development. While these interpretations of these relationships are preliminary, they may be instructive for university and corporate strategists who want to manage and optimize the contact points for their interactions.

Outcomes Data reduction resulted in nine different clusters of outcomes for industry respondents. These clusters were investments in new research/realized process outcomes, satisfaction/expected benefits, changes in research methods, realized product outcomes, personnel exchange, use of outside research contracts, outside research dollars, number of students interviewed and number of students hired. The pattern of correlations among the outcomes indicated that investments in new research/realized process outcomes was related to both the expectation of direct benefits and changes in the way research was conducted. Given that these data were cross-sectional, it cannot be determined if changes in research were contributing to other outcomes. However, these findings lend credence to the assumption that firms must make additional in-house investments to realize tangible product/process benefits from Center participation. In contrast, correlations suggest that firms which are active in personnel exchange reap benefits in the form of more students hired. Longitudinal data now being collected may shed some light on these dynamics.

For faculty respondents, outcomes grouped into seven factors. These were the likelihood of university benefits, changes in research, satisfaction, realized industry outcomes, industry satisfaction, improved ability of industry to cooperate with outside scientists and increased university patent activity. Satisfaction was correlated with perceptions of industry's increased ability to cooperate with outside scientists and with expected increased university patent activity.

Faculty satisfaction was significantly correlated with estimated industry satisfaction (.45, $p<.001$). Estimated industry outcomes were significantly correlated with the expectation of increased university patent activity (.46, $p<.01$). This correlation suggests that there was a relationship between how applied (patentable) the Center research was and the extent to which faculty perceived that companies realized benefits from participation.

Unfortunately, most of the outcome variables for faculty were subjective estimates of satisfaction and the likelihood of certain benefits. Thus, most of these findings were probably influenced by general optimism/satisfaction. Interestingly, reports of "differences in research", probably the most concrete variable in this group, did not correlate significantly with any of the other variables.

Correlations of Descriptor, Prior Contact, Current Operation and Goal Variables With Outcomes

Industry Respondents Of the nine benefit/outcome variables and composites, satisfaction/expected benefits, changes in research, use of outside research contracts, the dollar value of outside research contracts and the number of students hired were not

significantly correlated with any of the variables or composites from the other four domains.

New research/realized process outcomes was negatively correlated with seniority ($r=-.25$, $p\leq.01$), indicating that people with less seniority were more likely to report such outcomes. Greater enthusiasm in reporting outcomes, greater awareness of outcomes, or greater aggressiveness in pursuing research on the part of more junior respondents are all possible explanations for this finding.

Higher importance ratings for two goals, redirecting university research toward industrial goals ($r=.29$, $p\leq.01$) and technical goals ($r=.29$, $p\leq.01$), were also correlated with new research/realized process outcomes. Perhaps in those companies whose goals for the Center are more explicitly technical, industrial board members are more vigorous in pursuing such outcomes.

Five variables and composites were associated with realized product outcomes. From the respondent descriptors domain, seniority and number of levels to the CEO were both negatively correlated with outcomes ($r=-.22$, $p\leq.01$, and $r=-.33$, $p\leq.001$, respectively). These correlations indicate that respondents who were less senior and respondents who were at higher levels within their organizations (fewer levels from the CEO) were the most likely to report realized product outcomes. These variables were not correlated with each other, suggesting that there are two different types of respondents who are achieving product outcomes. These may be higher level people with the authority to pursue outcomes and younger people with the enthusiasm to do so. There is a clear need for more data on what these individuals are doing to achieve these outcomes.

From the current operations variable domain, involvement of marketing ($r=.38$, $p\leq.001$) and top management ($r=.54$, $p\leq.001$) were also correlated with realized product outcomes. It is likely that these groups become involved if and when new products are developed.

Finally, the importance of technical goals was correlated with realized product outcomes ($r=.42$, $p\leq.001$). Again, the explanation may be that these outcomes are pursued more vigorously where they are perceived as being more important.

Only one variable was correlated with the outcome of personnel exchange. Involvement of Central R&D, from the current operations domain, was correlated ($r=.23$, $p\leq.01$) with this outcome. Thus, visits by scientists were most likely to occur between the university and the functional group to which it is most similar, Central R&D.

The number of students interviewed was also correlated with only one variable, the importance of training goals ($r=.29$, $p.<01$). Companies which have a greater need for personnel may rate training goals as being more important.

Faculty Respondents Of the seven benefit/outcome variables and composites, satisfaction, realized industry outcomes and industry satisfaction were not significantly correlated with any variables or composites from the other domains.

The likelihood of university benefits was correlated with four variables. Interestingly, having a larger percentage of prior contacts with industry in the form of consulting was negatively correlated ($r=-.33$, $p\leq.01$) with the expectation of university benefits. Faculty who have had extensive consulting experience with industry are less optimistic about the likelihood of the university deriving benefits from their Center participation. It remains to be seen if these individuals are generalizing accurately from their consulting experiences to the different format used in Centers.

Conversely, the greater the involvement in the Center in terms of the number of research projects, the greater the perceived likelihood of university benefits.

Greater perceived influence of university administration and policy on the Center was also correlated ($r=.38$, $p\leq.01$) with the likelihood of university benefits.

Finally, higher importance of technical goals was also correlated with the likelihood of university benefits. Apparently, faculty who attach a greater importance to technical goals also see a greater likelihood of the university deriving benefits.

Changes in research was negatively correlated ($r=-.30$, $p\leq.01$) with perceived student influence. When student influence is strong, faculty may be less willing or able to alter accepted approaches to research.

The importance of training goals was correlated with perceived improvements in industry's ability to cooperate with outside scientists. This may occur due to an emphasis on people, rather than on the technical aspects of the research, where training goals are more important.

Technical goals were correlated ($r=.42$, $p\leq.001$) with the perceived likelihood of increased university patent activity. This may reflect an overall emphasis on technical rather than human resource aspects of the Center.

## Summary and Conclusions

The rapid growth of Centers sponsored by the National Science Foundation along with the development of state government and university sponsored centers based on this model appears to support the success of the IUCRC Program. Previously, Centers have been studied through case studies and been described at the macro-organizational level. By contrast, the current study examined Centers at the micro-organizational level by soliciting the views of Center participants.

These findings provide considerable evidence that Centers function as effective boundary spanning organizations between universities and industry. While Centers do not appear to have resulted in any radical changes in the structure or methodology of academic or industrial science, they do appear to function as effective technology transfer vehicles for industrially relevant fundamental research. Although both industry and and university participants have made concessions in the way they typically do business with each other, both report realistic and quite convergent goals, and exhibit relatively high satisfaction with

their collaboration. However, industry's lack of involvement in Centers may be a source of concern.

In addition, correlative analyses provide a basis for speculating about and potentially optimizing critical processes involved in the development of Centers, the interaction of industrial functional groups with Centers, and the relationship between various outcomes and personal and other characteristics of industrial representatives. The impending availability of data on additional Centers, as well as longitudinal data on these and other Centers, should help shed more light on the operation and outcomes of the IUCRC Program.

# CHAPTER 1
# OVERVIEW OF THE STUDY

## INTRODUCTION

This report presents the results of a survey of participants in the National Science Foundation's Industry/University Cooperative Research Centers (IUCRC) Program. The purpose of the IUCRC Program is to promote more rapid technological innovation by creating linkages between industry and university scientists. The Program involves the systematic replication of an organizational model developed through the Experimental R&D Incentives Program, and originally implemented in the mid-1970's as the Polymer Processing Center, at the Massachusetts Institute of Technology (see Colton, 1982, for more background on this).

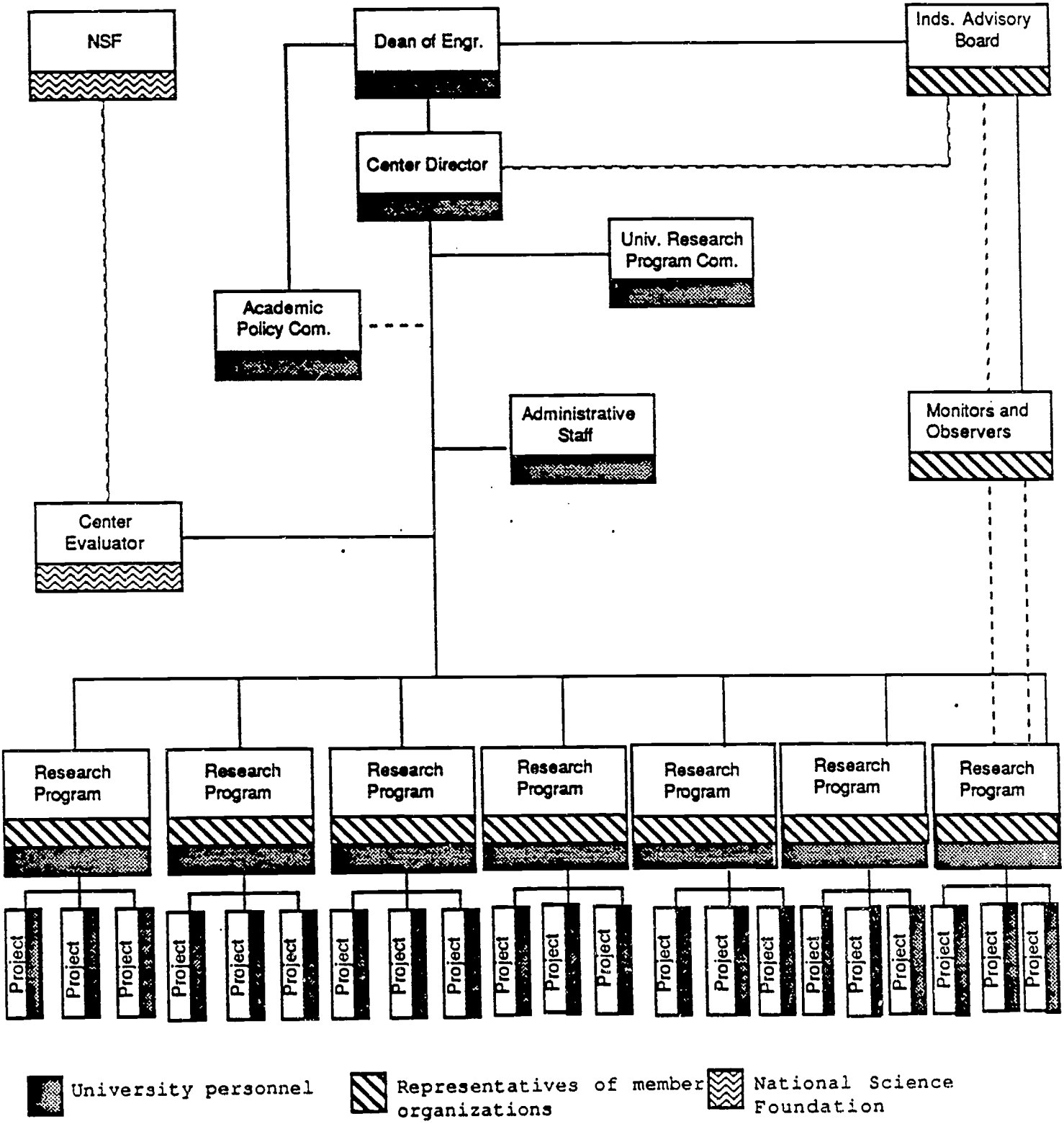
Over the past decade, the National Science Foundation has sponsored the development of twenty-nine "Industry/University Cooperative Research Centers" ("Centers") in a number of locations and a variety of technical areas. These Centers are university research groups consisting of an administrative core which supports and coordinates a series of interrelated research projects, each of which involves several faculty, staff, and students. Figure 1 presents a typical organizational chart for a Center. While NSF funding partially supports the initial development of a Center, sustaining support is provided by a group of industrial firms, the "sponsors", in the form of an annual membership fee. Projects are monitored by scientific personnel from the sponsoring firms ("technical monitors"). An "Industrial Advisory Board", working with Center management, provides guidance on general policies, research directions and emphases, and resource allocations. The key characteristic which distinguishes a Center from other more traditional forms of industry support for academia is the commitment of a group of firms to the collective support of a program of research. Each individual component of the research program may be more or less central to any one firm.

### The NSF IUCRC Program

Centers are developed with the benefit of both grants and technical assistance from the NSF. During the earliest stage of Center development, NSF awards a one-year planning grant to university principal investigators (PIs) who exhibit the scientific and organizational potential to organize and run a Center. These grants have been quite modest, usually allowing for considerably less than one person-year of professional time. If the university is successful in recruiting enough companies and in developing a quality research program, an operating grant is awarded. In the past, funds for an operating grant have provided from 10-15% to as high as one half of a Center's operating costs during its first couple of years. In general, Centers receive five-year funding commitments from NSF and considerable technical assistance from the NSF Program Manager:

# FIGURE 1

## Organizational Chart of a Typical IUCRC




Source: Gray, et al., in press, p.179. Reprinted by permission of the authors.

> During the six year process described above, a Program Manager from NSF interacts continuously with individuals who submit grants and the eventual center directors. The role assumed by the NSF representative in these dealings more closely resembles an involved cooperative extension agent who provides advice and technical assistance than a detached grant manager. The Program Manager, based on his experience with other centers, advises the applicant or center director on the problems and pitfalls of designing a center, securing university support and industrial commitments, concensus building on a research agenda that will appeal to industry and the optimal policies and procedures for the center's administration. This active involvement of the Program Manager in the process of building a center may be the most unusual and unique feature of the Centers Program (Gray, Hetzner, Eveland, & Gidley, in press).

Since NSF funds decrease beginning in year three and end after five years, Centers must replace NSF dollars with additional industry or state dollars (requiring industry to increase its membership fee or increase the number of members, or both).

At this writing, all three Centers which have finished their NSF funding (the prototype Center at MIT, the Center for Interactive Computer Graphics at RPI and the Center for University of Massachusetts/Industry Research on Polymers) have become self-sustaining. During the coming years, all of the Centers will have to make this transition. This report includes data from the first eight NSF Centers (excluding the MIT prototype Center):

1) The Center for Interactive Computer Graphics (Renssalaer Polytechnic Institute) (began operation 1978),

2) The Center for Welding Research (Ohio State University) (began operation July, 1980),

3) The Center for University of Massachusetts/Industry Research on Polymers (began operation September, 1980),

4) The Center for Applied Polymer Research with Industry (Case Western Reserve University) (began operation June, 1981),

5) The University/Industry Cooperative Center for Robotics (University of Rhode Island) (began operation February, 1982),

6) The Ceramics Cooperative Research Center (Rutgers University) (began operation July, 1982),

7) The Cooperative Research Center for Communications and Signal Processing (North Carolina State University) (began operation July, 1982), and

8) The Material Handling Research Center (Georgia Institute of Technology) (began operation October, 1982).

While the present analysis will provide some insight into the short-term outcomes of the Centers, we will have to wait until more Centers mature and become independent of NSF to assess the long-term outcomes of the program. However, at this time no data collection or evaluation of self-sustaining Centers is underway or planned.

The Assessment Process

The Centers constitute a series of institutional experiments which have potentially significant technological, economic and organizational costs as well as payoffs. However, the outcomes and mediators of these institutional experiments have been virtually unknown. Beginning in 1979-80, the Productivity Improvement Research Section (PIR) of NSF's Division of Industrial Science and Technological Innovation (ISTI) and other ISTI staff were given responsibility for conceptualizing, developing and implementing a series of studies of Centers which might explain how Centers work and what their outcomes are.[1]

While PIR staff were responsible for the overall planning and coordination of the evaluation effort, the data collection was actually carried out by an evaluator at each Center. The National Science Foundation mandated that part of the funds awarded for Center operating grants be used for an evaluation of the Center. Each Center director contracts with someone to conduct this evaluation. The evaluator is usually a member of a department within the university that is not involved in the operation of the Center (for example, business school or psychology faculty). Each evaluator follows a common three-tier assessment protocol.

The first component of the assessment is the "documentation" effort, an attempt to maintain an ongoing picture of what the Center is and how it got that way. The purpose of this part of the evaluation program is to record events which are pertinent to the development of the "organizational learning" of the Centers -- learning about their environments, capabilities, and contributions. These reports are updated annually by the on-site evaluator. University-Industry Cooperative Research Centers: Historical Profiles (Eveland, Hetzner and Tornatzky, 1984) and University-Industry Cooperative Research Centers: A Practice Manual (Tornatzky, Hetzner and Eveland, 1982) document this component of the evaluation effort.

The second component of the evaluation is the network analysis of the frequency, mode and content of interaction between and among university and firm participants. The network analysis is an attempt to document who talks to whom, about what, how often and by what mode (i.e. personally, by telephone, through meeting or in writing). The analysis includes not only

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[1] In 1985, the management of the Centers Program was transferred to the Engineering Directorate. PIR was disbanded the same year.

active participants in the Center, but also individuals in the sponsoring firms or university who may be the ultimate users of the research results.

This information is collected using a standard network instrument which is administered at the end of the first year of a Center's grant and in the year that NSF funding runs out. The results of this instrument are analyzed using NEGOPY, one of the more widely used versions of computer routines for turning large contact matrices into a usable set of descriptive indices. First-year results of this analysis for eight Centers are reported in Communications Networks in University/Industry Cooperative Research Centers (Eveland, 1985).

The third component of the evaluation, presented in this report, is the structure and outcome assessment. During each year of NSF funding, data are gathered by questionnaire from all Center participants -- industrial board members, technical monitors, Center administrative staff, faculty and graduate students. These questionnaires are designed to measure variables in five domains: characteristics of the respondent, prior contact/Center initiation, current operations, goals, and outcomes.

This report provides an analysis and summary of the first wave of the data generated by the final component of the evaluation effort. Future reports will examine subsequent waves of data (based on current and new Centers) and where possible will examine changes in Centers over time. It is hoped that this report and future reports will provide information which is useful in initiating and managing both NSF Centers and the growing number of centers which resemble the NSF model but are funded by non-NSF sources. On the other hand, it should be noted that the most useful insights into the operation of Centers are likely to emerge from the integration of data derived over time from different assessment components rather than from any one component by itself. A preliminary summary of findings on Center operations and the innovation process which draws on the complete evaluation effort can be found elsewhere (Gray et al, 1986).

The following sections describe the methods and procedures of the structure and outcome component of the evaluation.

## METHODS AND PROCEDURES

### Design

The study was a structured survey of the participants in the Industry-University Cooperative Research Centers Program.

### Sample & Respondents

The sample for this phase of the study consisted of eight Centers which had been in operation at least one year by November, 1983. A total of 133 industry people and 65 faculty members were surveyed. The number of faculty per Center ranged from six to seventeen the number of industry respondents per Center ranged from seven to twenty-two. At most centers the questionnaire was given only to industrial advisory board members. However, due to confusion and the fact that multiple individuals filled the role of board member at other Centers, more than one person per company completed questionnaires at some Centers. This resulted in twenty-one companies at the four Centers being weighted by having multiple respondents.[2] (Two respondents at seventeen companies, three at four). There were 106 companies included in the total sample. Since it was not possible to separate the board members from the other respondent (usually a monitor), all respondents are included for all analyses except the descriptive analyses involving numbers of dollars, persons and research projects. For these analyses, multiple responses from a single company were averaged. However, if one respondent indicated a zero and another reported some activity, the non-zero response was used.

### Instruments

The data collection instruments for industry and faculty were roughly parallel in form. The ten page industry questionnaire (Appendix A) included 35 questions and 93 variables; the seven page faculty questionnaire (Appendix B) included 12 questions and 87 variables. The questionnaires were designed to measure the five categories of data described below. Appendix C contains a listing of all variables by category for both respondent groups. Numbers in parentheses after each heading refer to question numbers on these instruments (I=industry:Appendix A; F=faculty:Appendix B). Open-ended questions were not coded for this study.

[2]For ease of discussion, we are referring to the 106 memberships as separate companies. In fact, several companies have memberships at more than one Center.

1) Respondent descriptors. (I = 1,2,3,4,6,7,8; F = 3)

For industry respondents, the eight variables in this category were the number of years in the company, number of years in R&D in the company, number of years in industry, number of years in R&D in industry, number of levels between respondent and chief executive officer, the number of subordinates reporting directly to the respondent, the number reporting through others, and the highest degree held by the respondent. The first seven variables were coded using the number provided by the respondent. The highest degree held was coded on a five-point scale (1=High School, 5=PhD).

For faculty respondents, there were two variables in this category: tenure status and academic rank. The former was coded on a two-point scale (1=no, 2=yes); the latter was coded on a four point scale (1=assistant professor, 4=other).

2) Prior contact/Center initiation. (I = 9,10,11,12,15,16; F = 1,2)

Forindustry respondents, these variables were: whether or not the respondent had received a degree or taken courses at the Center university (coded 1 or 2), how frequently they interacted with Center personnel prior to the establishment of the Center (1=rarely or never, 4=several times per week), the number of organizational levels that had to approve joining the Center (number coded), the number of individuals at the same level who had to concur with the decision (number coded), the types of prior contact with Center affiliated personnel (coded 1 if checked, 0 if not checked for seven possible types of contact, i.e. contract research, consulting, student exchange, etc.), and the types of Center planning activities in which the respondent was involved (coded 1 if checked, 0 if not checked for six possible activities, ie. organizing meetings, recruiting member companies, proposal writing, etc.).

For faculty respondents, the variables in this category included the percentage of their prior contacts with industry that were in the form of consulting, contract research, faculty exchange, supervision of student exchange or other type. The percentage given was coded for each type of contact. The other variable in this category was the frequency of prior interaction with member companies, coded separately for each company (1=rarely or never, 4=several times per week).

3) Goals. (I = 25; F = 9)

Both faculty and industry respondents rated the importance of eight possible goals for the Center on a four point scale (1=not at all important, 4=extremely important). The eight goals were general expansion of knowledge in the technical area, enhancement of graduate students' technical training, enhancement of graduate students' understanding of industry, redirection of university research toward industry needs, enhancement of the .pa quality of industrial research, development of new research

projects in the firm, development of patentable products in the firm, and development of commercialized products in the firm.

4) Current operations. (I = 13,14,17,20; F = 3,4)

For industry respondents, variables in this category included the total cost of participation in the Center beyond the annual membership fee (number coded in thousands), the extent to which top management was involved in the Center (1=not at all, 4=completely), the extent to which seven functional groups interacted with the Center (0=not checked, 2=regularly), and the respondent's involvement in six Center administrative activities, such as organizing meetings, proposal writing and recruitment of new members (coded 1 if checked, 0 if not checked).

For faculty respondents, there were 39 variables in this category. Thirty-six of these were the ratings of the influence of six groups on six areas of Center functioning. The influence of university administration, the Center director, the faculty, the industrial advisory board, students, and established university policies on planning, project selection, the conduct of the research, the evaluation of the research, budget and logistics, and faculty and staff appointments were rated on a four-point scale (1=none, 4=complete). The other variables in this group were the number of outside groups who are involved with the Center (number coded),the percent of respondents' time spent on Center-related research (number coded), and the number of Center research projects in which the respondent is involved (number coded).

5) Outcomes. (I = 22,26-35; F = 7-12)

For industry respondents, the variables in this category included satisfaction, both general and with specific components such as communication and responsiveness to industry (1=not at all satisfied, 4=completely satisfied); a rating of the overall research program compared to similar programs (1=below average, 4=top 2%); an indication of whether or not the Center's goals are realistic (1=no, 3=yes); the likelihood of four benefits, such as improved research projects and better personnel recruitment (1=scarcely likely, 4=almost certain); four measures of new research generated by involvement in the Center (number of projects, research dollars, percent of total R&D and staff-time in full-time equivalents, all coded as the number given); new contract research generated by involvement in the Center (1=no, 2=yes) and the dollar value of it (number coded in thousands); changes in the research topics, methods and procedures (1=hardly any, 4=a lot); indications of whether or not changes had occured in eleven other areas, such as improvements in products or services, reduction of production costs, and improved capability to cooperate with outside scientists (1=no, 3=yes); the numbers of company scientists who had spent time working on-site at the Center and vice versa (number coded); and the numbers of students interviewed and hired by the respondents' companies (numbers coded).

For faculty respondents, many of the same variables were included in this category: ratings of their own satisfaction, their estimates of industry satisfaction, their estimate of the extent to which the eleven areas of change described above had taken place in participating companies, and the extent to which research topics, methods and procedures were different from their typical research. Additionally, there was a measure of the faculty members perception of how participation in the Center would affect their chances for promotion and tenure (1=not at all, 4=great deal).

## Data collection

Data were collected by the on-site evaluator for each Center. At most centers questionnaires were mailed to respondents accompanied by a letter of support from the Center Director. In some Centers the questionnaires were handed out to respondents during a meeting and returned by mail.

## Analysis

Two types of analyses were performed. The first of these was decriptive in nature, attempting to describe the distribution of responses to a question and/or the "average" Center. Included in this approach was some comparison between industry and faculty respondents. Results of this analysis are presented in Chapter Two.

The second type of analysis attempted to make relational statements about what variables "predict" outcomes. Various data reduction strategies were used to create a workable number of variables. Correlational analyses were then performed on these variables. Results of these analyses are presented in Chapter Three.

# CHAPTER 2
# DESCRIPTIVE RESULTS

This chapter will provide an overview of the descriptive findings in each category of data. In most cases, means are discussed; however, where standard deviations are large or there are extreme outliers, medians will be discussed. Variables for which the response rate was low or the variance minimal are not included in this discussion (see Appendix D for more information on these variables).

Where parallel data exist, comparisons will be made between industry and university respondents. Although these data represent a population, making probability statements superfluous, results of tests of significance are reported using alpha of .05 or below in order to help focus the discussion.

## Respondent Descriptors

Industry respondents. (Table 1) Industry respondents were a mix of industrial advisory board members and technical monitors. The respondents tended to be mid- to senior-level people with extensive experience both in industry and in R&D. They had worked in industry an average of 22.5 years with 14.7 years in R&D. They had been with their present companies an average of 16.2 years, with 11.5 of these in R&D. There was a great deal of variability around these averages; all standard deviations were in the range of 8 to 10 years.

Respondents were an average of 3.5 levels from the CEO. There was a great deal of variability in the number of subordinates reporting to them; the median was 4.0 reporting directly and 6.7 reporting through others.

The highest degree held by 31.5% of the respondents was a BA/BS; 26.8% held a masters degree and 37.8% held a Ph.D.

Faculty respondents. (Table 2) Faculty researchers involved with the Centers tended to come from all ranks, but the majority (63.7%) were tenured. The largest proportion were at the rank of associate professor (36.4%). Another 31.8% were full professors. Approximately one-fifth (20.5%) of the faculty respondents were assistant professors, while 11.4% used "other" to describe their status. The latter were probably post-doctoral researchers or non-tenure track research associates.

Summary. On the average, industry respondents had long tenure both in industry in general and in R&D in particular. They tended to be relatively highly placed within their companies. However, there was considerable variability around these averages.

While the majority of faculty were tenured faculty members, approximately one-third of all university participants were assistant professors or post-docs. Thus, a significant number of junior faculty were working with their more senior colleagues on Center research.

TABLE 1

INDUSTRY RESPONDENTS
DESCRIPTORS

| Descriptor | Mean | Median | Std. Dev. |
|---|---|---|---|
| How many years with company? | 16.2 | 15.6 | 10.1 |
| How many years R&D with company? | 11.5 | 9.7 | 9.7 |
| How many years spent in industry? | 22.5 | 22.3 | 9.0 |
| How many years in R&D with industry? | 14.7 | 14.9 | 10.1 |
| How many levels between you & CEO? | 3.5 | 3.3 | 2.3 |
| How many report to you directly? | 9.3 | 4.0 | 45.3 |
| Through others? | 63.2 | 6.7 | 156.2 |

| Highest degree received | N | % |
|---|---|---|
| HS (1) | 0 | - |
| AA/AS (2) | 4 | 3.1 |
| BA/BS (3) | 40 | 31.5 |
| MA/MS (4) | 34 | 26.8 |
| PhD (5) | 48 | 37.8 |
| | 126 | |
| Mean | 3.97 | |

TABLE 2

FACULTY RESPONDENTS
DESCRIPTORS

| | N | % |
|---|---|---|
| Academic rank | | |
| Assistant | 9 | 20.5 |
| Associate | 16 | 36.4 |
| Full | 14 | 31.8 |
| Other | 5 | 11.4 |
| | 44 | |
| Tenure status | | |
| Tenured | 31 | 63.3 |
| Not tenured | 18 | 36.7 |
| | 49 | |

Prior Relationships

Industry respondents. (Table 3) Of the industry respondents, 17.6% had taken courses or received their degree from the Center university. Surprisingly, the majority (55.8%) reported that they rarely or never had contact with personnel affiliated with the Center prior to their company's participation in it. An additional 41.1% reported prior contact several times per year. Only 3.2% had prior contact several times per month or more often.

Industry respondents were asked to indicate the modes of prior contact which their company had with Center personnel prior to their participation in the Center. The most frequent type of contact was the use of faculty as consultants (35.6% of respondents), followed by "other" types of contact (23.5%), general support of faculty research (18.9%), and contract research (16.7%). Fewer than 15% of industry respondents reported prior contact in the form of supporting student research, or faculty or student exchange. Forty-five percent of all respondents failed to check any mode of contact and as indicated above apparently had no prior contact with Center personnel.

Faculty respondents. (Table 4) Faculty respondents reported that the largest percentage of their prior contact with industry was in the form of individual consulting (median, 31.7%). The next most frequent type of contact was through contract research projects (median, 10.7%), followed by "other" contact (1.6%).

Paralleling the industry respondents, faculty reported a low frequency of prior contact with industry before their participation in the Center. Rather than rating their overall frequency of prior contact with industry, faculty rated the frequency of their prior contact with each of the member companies belonging to their Center (1 = Rarely or never, 2 = Several times/year, 3 = Several times/month, 4 = Several times/week). Using this scale a mean frequency of interaction across all companies was computed for each faculty member. The overall mean frequency for all faculty respondents was 1.27. This again indicates relatively infrequent contact with companies now involved with the Centers.

Summary Many of the people brought together by Centers had had infrequent or no prior contact. The majority of the prior contact between industry people and faculty members was in the form of consulting arrangements.

Center Initiation

Industry respondents (Table 5) The low level of prior contact reported above continued throughout the period of Center initiation. Over two-thirds (69.2%) of respondents indicated they had no involvement in any of the Center planning activities. Another 15% reported involvement in only one of the start-up activities. Those activities most frequently engaged in were "organizing meetings" (14.4%) and "planning" (13.6%).

TABLE 3

INDUSTRY RESPONDENTS
PRIOR RELATIONSHIPS

A. Do you have a degree from or have you taken course work at the Center University?

| | N | % |
|---|---|---|
| YES | 23 | 17.6 |
| NO | 108 | 82.4 |
| | 131 | |

B. Prior to the participation of your company in the Center, how frequently did you personally have contact with personnel now affiliated with the Center?

| | N | % |
|---|---|---|
| Several times per week (4) | 2 | 1.6 |
| Several times per month (3) | 2 | 1.6 |
| Several times per year (2) | 53 | 41.1 |
| Rarely or never (1) | 72 | 55.8 |
| | 129 | |
| Mean | 1.49 | |

C. Prior to participation of your company in the Center, was your company involved in any of the following activities with university personnel now associated with the Center? (Check all that apply)

| | N | % |
|---|---|---|
| Use of faculty as consultants | 47 | 35.6 |
| Contract research projects | 22 | 16.7 |
| General support of faculty research | 25 | 18.9 |
| Support of student thesis research | 17 | 12.9 |
| Faculty exchange | 7 | 5.3 |
| Student exchange | 16 | 12.1 |
| Other | 31 | 23.5 |

(continued)

Table 3 (cont.)

| Totals | N | % |
|---|---|---|
| None checked | 58 | 43.6 |
| One checked | 31 | 23.3 |
| Two checked | 18 | 13.5 |
| Three checked | 15 | 11.3 |
| Four checked | 6 | 4.5 |
| Five checked | 2 | 1.5 |
| Six checked | 2 | 1.5 |
| Seven checked | 1 | .8 |
| Mean number checked | 1.24 | |

(Percents may not equal 100 due to rounding error.)

TABLE 4

FACULTY RESPONDENTS
PRIOR CONTACT

A. Approximately what percentage of your contacts with industry prior to the Center have been of the following types?

| | Mean % | Median % | Std. Dev. |
|---|---|---|---|
| Individual consulting | 41.1 | 31.7 | 36.4 |
| Contract research projects | 23.5 | 10.7 | 30.2 |
| Faculty exchange | 2.3 | .3 | 12.5 |
| Supervision of student exchange | 3.7 | .5 | 9.7 |
| Other | 21.8 | 1.6 | 34.2 |

B. Prior to the establishment of the Center, how frequently did you have contact with individuals from the following member companies? [List of all member companies followed.]

Several times/week (4)
Several times/month (3)
Several times/year (2)
Rarely or never (1)

| Mean % | Median % | Std. Dev. |
|---|---|---|
| 1.27 | 1.25 | .23 |

TABLE 5

INDUSTRY RESPONDENTS
CENTER INITIATION

A. Were you involved in any of the following activities prior to the establishment of the Center? (Check all that apply)

| | N | % of all Respondents |
|---|---|---|
| Recruitment of new member companies | 8 | 6.1 |
| Organizing meetings | 19 | 14.4 |
| Proposal writing | 12 | 9.1 |
| Planning | 18 | 13.6 |
| Building support within the University | 4 | 3.0 |
| Other | 10 | 7.6 |

| Totals | N | % |
|---|---|---|
| None checked | 92 | 69.2 |
| One checked | 20 | 15.0 |
| Two checked | 13 | 9.8 |
| Three checked | 7 | 5.3 |
| Four checked | 1 | .8 |

Mean number checked .53

B. How many organizational levels in your firm had to give explicit approval to your participation in the Center?

| Mean | Median | Std. Dev. |
|---|---|---|
| 2.3 | 2.1 | 1.2 |

C. How many individuals at your level in your company had to concur with the decision to participate in the Center?

| Mean | Median | Std. Dev. |
|---|---|---|
| 1.9 | 1.2 | 4.0 |

(Percents may not equal 100 due to rounding error.)

At the companies, an average of two or three organizational levels had to approve joining the Center. On the average only one or two individuals at the respondent's level had to give approval to join the Center (although there was considerable variance on this response, s.d.=4). This suggests a relatively simple decision-making process was needed to secure membership approval in most companies.

Current Operations

Industry respondents. (Table 6) Respondents were asked to indicate the extent of both their own involvement in Center administrative activities and the administrative and financial involvement of their companies.

At the individual level, over half (54.1%) of the respondents failed to indicate involvement in any of six administrative activities. The activity most frequently indicated was "Planning", which was checked by 28.6% of all respondents. The next most frequently checked activity was "Other" (18.8%). Almost 16% indicated involvement in organizing meetings. Less than 6% indicated involvement in any of the other activities listed.

At the company level, participation in the Center entails costs in addition to the yearly membership fee. These costs include transportation to meetings, staff time and in some instances space at the company. There was a great deal of variability in these costs. The median cost of Center participation was $7.5 K in addition to the annual membership fee.

On the average, two or three functional groups at member companies worked directly with the Center (mean, 2.24). Almost 75% of all respondents indicated two or more groups were involved with the Centers. The groups most involved with the Centers were Engineering/technical staff (63.1% of respondents), Central R&D staff (60.2%), and Divisional R&D staff (51.1%). Marketing, Corporate planning and Production staffs were not involved in the Centers in most instances.

At most companies, top management was not extensively involved in Center activities. Only 13.6% of companies reported that top management was involved "considerably" or "completely." Almost 60% reported "some" involvement and 35% checked "not at all" to describe the extent of top management involvement.

Industry respondents also were asked to indicate the number of requests for information on the Center they had received from people within their company. The median was 5.72 such requests. The vast majority (median, 89.7%) of these requests were technical in nature.

Faculty respondents. (Table 7) Most faculty members were involved in one (53.2%) or two (29.0%) projects at the Center. There was considerable variability in the amount of time spent on Center projects with the median being 25%.

Summary. Industrial advisory board members and technical monitors were not involved in the day-to-day administration of the Centers. Not surprisingly, top management was not heavily involved in Center activities. However, in most instances two or

TABLE 6

INDUSTRY RESPONDENTS
CURRENT OPERATIONS

A. Do you currently take an active role in any of the following activities of the Center? (Check all that apply.)

| | N | % of all Respondents |
|---|---|---|
| Recruitment of new member companies | 6 | 4.5 |
| Organizing meetings | 21 | 15.8 |
| Proposal writing | 7 | 5.3 |
| Planning | 38 | 28.6 |
| Building support within the university | 3 | 2.3 |
| Other | 25 | 18.8 |

| Totals | N | % |
|---|---|---|
| None checked | 72 | 54.1 |
| One checked | 34 | 25.6 |
| Two checked | 16 | 12.0 |
| Three checked | 10 | 7.5 |
| Four checked | 1 | .8 |
| | 133 | |

Mean number checked .75

B. What is the approximate total cost of your company's participation in the Center in addition to yearly fees?

| Mean | Median | Std. Dev. |
|---|---|---|
| 14.5K | 7.5K | 27.9 |

(continued)

Table 6 (cont.)

C. What functional groups in your company work directly with the Center? (Check all that apply.)

| | N | % Occasionally and Regularly |
|---|---|---|
| Central R&D staff | 80 | 60.2 |
| Divisional R&D staffs | 68 | 51.1 |
| Production staff | 19 | 14.3 |
| Marketing staff | 14 | 10.5 |
| Engineering/technical staff | 84 | 63.1 |
| Corporate planning staff | 24 | 18.0 |
| Other | 9 | 6.8 |

| Totals | N | % |
|---|---|---|
| None checked | 1 | .8 |
| One checked | 35 | 26.3 |
| Two checked | 49 | 36.8 |
| Three checked | 32 | 24.1 |
| Four checked | 13 | 9.8 |
| Five checked | 1 | .8 |
| Six checked | 2 | 1.5 |
| | 133 | |

Mean number checked 2.24

D. To what extent is your top management involved with the activities of the Center?

| | N | % |
|---|---|---|
| Completely (4) | 2 | 1.5 |
| Considerably (3) | 16 | 12.1 |
| Some (2) | 67 | 50.8 |
| Not at all (1) | 47 | 35.6 |
| | 132 | |

Mean 1.80

(continued)

Table 6 (cont.)

E. Approximately how many people in your company have requested information from you concerning specific activities or projects of the Center?

| Mean | Median | Std. Dev. |
|---|---|---|
| 10.45 | 5.72 | 12.94 |

| Number of requests | N |
|---|---|
| 0 | 7 |
| 1-5 | 56 |
| 6-10 | 38 |
| 11-15 | 7 |
| 20-25 | 13 |
| 26+ | 9 |
| | 130 |

Approximately what percentage of these information requests can be classified as technical in nature?

| Mean | Median | Std. Dev. |
|---|---|---|
| 78.26% | 89.70% | 27.36% |

| % of requests | N |
|---|---|
| Less than 90% | 60 |
| 90% or more | 69 |
| | 129 |

Approximately what percentage concerns administrative or operational issues of the Center?

| Mean | Median | Std. Dev. |
|---|---|---|
| 15.94% | 9.91% | 20.93% |

| % of requests | N |
|---|---|
| Less than 90% | 127 |
| 90% or more | 3 |
| | 130 |

(Percents may not equal 100 due to rounding error.)

TABLE 7

FACULTY RESPONDENTS
CURRENT OPERATIONS

| A. Number of projects involved in | N | % |
|---|---|---|
| 0 | 1 | 1.6 |
| 1 | 33 | 53.2 |
| 2 | 18 | 29.0 |
| 3 | 4 | 6.5 |
| 4 | 6 | 9.7 |
| Mean 1.69 | | |

B. Percent time allocated to Center projects

| Mean | Median | Std. Dev. |
|---|---|---|
| 36.3 | 25.0 | 32.2 |

(Percents may not equal 100 due to rounding error.)

more functional groups were involved with a Center. At the companies, R&D (Central and Divisional) and Engineering/technical groups were typically the ones which worked with the Centers. Top management was not heavily involved in Center activities. There was a great deal of variability in the additional costs of Center participation. This variability was probably attributable to geographic distance from the Center and the number of people sent to meetings, among other factors.

Most respondents received a few requests for information on Centers (median, 5.72). Almost 90% of these requests were technical in nature. Since the survey did not ask what mechanisms respondents used to actively disseminate information, there is no way of knowing if this relatively low number of people requesting information was due to adequate information already being available, lack of interest, or lack of awareness of the Center and its activities.

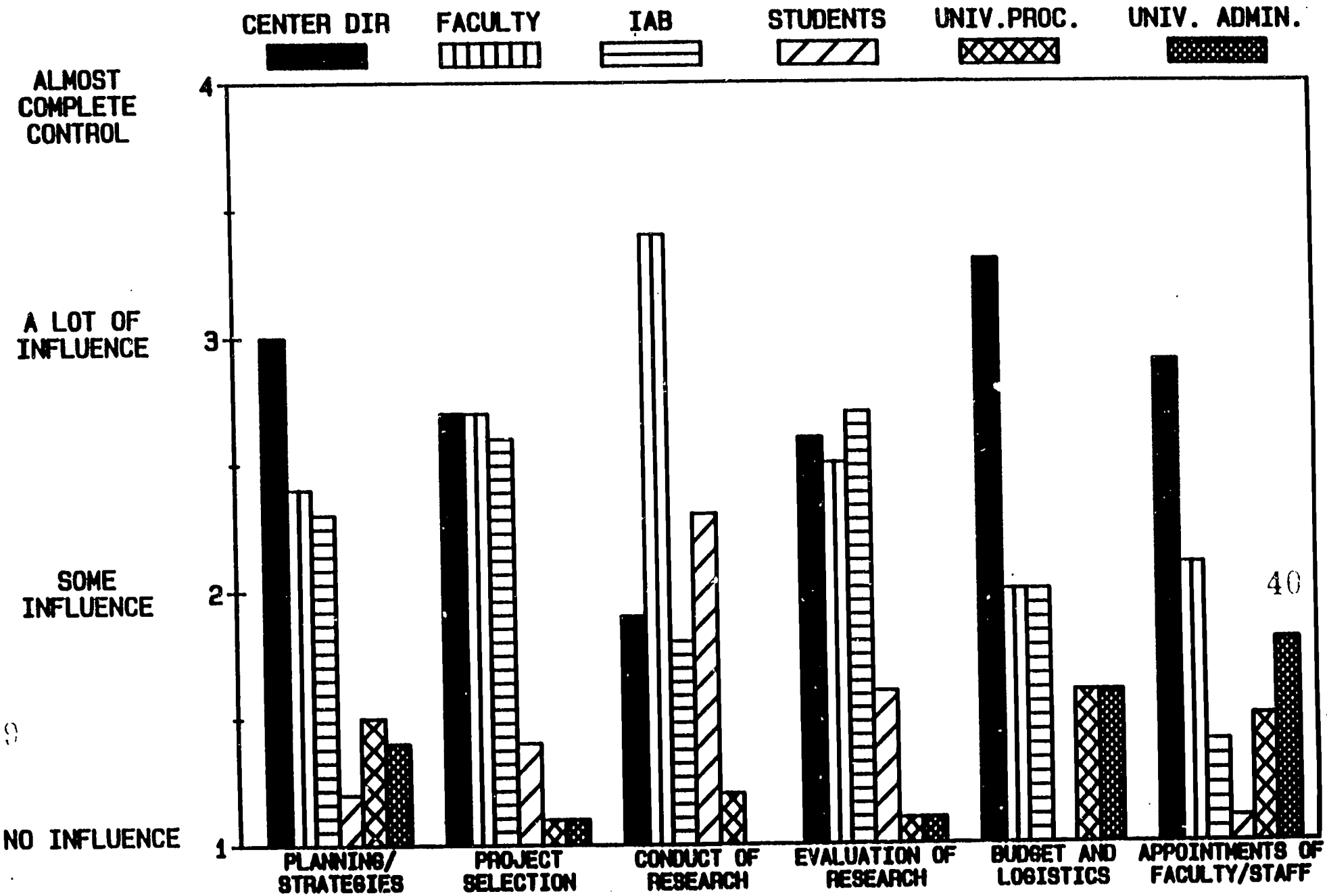
A large proportion of most faculty members' time (median, 25%) was devoted to Center-sponsored research. Not surprisingly, given the structure of a Center and the roles assumed by participants, the faculty who conduct the research were considerably more involved in the Centers than the industry people, who primarily help set policy and/or monitor the research activities.

Faculty respondents: Influence ratings. (Figure 2) Faculty were asked to evaluate the influence of various groups on several aspects of Center functioning. Influence was rated on a four point scale ranging from one (no influence) to four (almost complete control). Faculty see themselves as being the most influential group in the actual conduct of the research (mean, 3.40); students are seen as the second most influential in this area (mean, 2.21). Faculty and the Center directors were rated about equally on their influence on project selection (2.72 and 2.67, respectively), with the industrial advisory board not far behind (2.56). Center directors were rated as the most influential in planning and strategy (3.00), budget and logistics (3.30), and appointments of faculty and staff (2.93). Industrial advisory board members were seen as being the most influential in evaluation of the research (2.72). University administration and university procedures were seen as having relatively little influence on any of these aspects of the Center.

Summary. The faculty's perceptions of the influence of these six elements indicates a sharing of roles among those involved in the Centers. Center directors were seen as being most influential in administrative areas, faculty as most influential in the conduct of the research, and industrial advisory board members in the evaluation of the research. Project selection was seen as being most influenced by faculty, although Center directors and industrial advisory boards also had a large amount of influence in this area. These perceptions reinforce industry respondents' report that they were not involved in the day-to-day operations of the Centers.

# FIGURE 2

## Faculty Respondents Influence Ratings



Industry respondents. (Table 8) Using a scale of one (not at all important) to four (extremely important), industry respondents were asked to rate the importance of eight specific goals for their Center. Based on mean ratings, four goals were rated as being between considerably and extremely important: expansion of general knowledge (3.6), enhancement of graduate students' understanding of industry (3.02), redirection of university research toward industrial problems (3.02), and enhancement of the quality of industrial research (3.10). Enhancement of graduate student technical training followed closely (2.98). The least important goals were the development of new research projects in the firms (2.61), the development of commercialized products in the firms (2.14) and development of patentable products (1.93).

Industry respondents were asked to indicate whether or not the goals of the Center were realistic. The majority of respondents believe that their Center has established realistic goals (76.7%). Another 22.6% believe that the goals "may be" realistic. Only one respondent (.8%) said the goals were not realistic.

Faculty respondents. (Table 8) Based on mean ratings, faculty rated two of the eight proposed goals as being between "considerably" and "extremely" important: general expansion of knowledge in the technical area (3.66) and enhancement of graduate student technical training (3.37). Enhancement of the quality of industrial research was the third-highest ranked goal (2.92), followed by redirection of university research toward industrial problems (2.56), development of patentable products in sponsoring firms (2.12) and development of commercialized products in the firms (1.86).

Industry/Faculty Comparison. (Table 8 and Figure 3) The rankings of goals based on industry and faculty importance ratings were remarkably similar. Both rated general expansion of knowledge as the most important goal and the more applied outcomes (new research projects and patentable and commercialized products) as the least important goals. Faculty believed that enhancement of graduate student technical training was more important than did the industry respondents ($t=3.35$, $p<.001$). Industry rated two goals significantly higher than did the faculty: enhancement of graduate students' understanding of industry ($t=3.04$, $p<.01$) and redirection of university research toward industrial problems ($t=2.66$, $p<.01$).

Withstanding these relatively minor differences, the ratings of specific goals by industry and faculty were very similar. In order to determine if this similarity held up within individual Centers, Spearman correlations were computed on the ranks. The median correlation between respondent groups within a Center was .78.

Summary. Overall, there was considerable congruence in the goal importance ratings between the two respondent groups. Both faculty and industry respondents rated general expansion of knowledge as the most important goal and the more short-term goals of patent and product development as the least important.

TABLE 8

INDUSTRY AND FACULTY RESPONDENTS
GOALS

A. Do you think that the Center has established realistic goals and objectives? (Industry respondents.)

| | N | % |
|---|---|---|
| YES (3) | 102 | 76.7 |
| MAYBE (2) | 30 | 22.6 |
| NO (1) | 1 | .8 |
| | 133 | |
| Mean | 2.76 | |

B. How important to you are the following goals and outcomes of the Center?

| | Mean* (Std. Dev.) | | Rank | |
|---|---|---|---|---|
| | Industry | Faculty | Industry | Faculty |
| General expansion of knowledge in this technical area | 3.60 (.604) | 3.66 (.614) | 1 | 1 |
| Enhancement of graduate student technical training[1] | 2.98 (.824) | 3.37 (.678) | 5 | 2 |
| Enhancement of graduate students' understanding of industry[2] | 3.02 (.830) | 2.64 (.804) | 3.5 | 5 |
| Redirection of university research toward industrial probiems[3] | 3.02 (.881) | 2.66 (.946) | 3.5 | 4 |
| Enhancement of quality of industrial research | 3.10 (.870) | 2.92 (.842) | 2 | 3 |
| Development of new research projects in your firm | 2.61 (.973) | 2.56 (.934) | 6 | 6 |

(continued)

Table 8 (cont.)

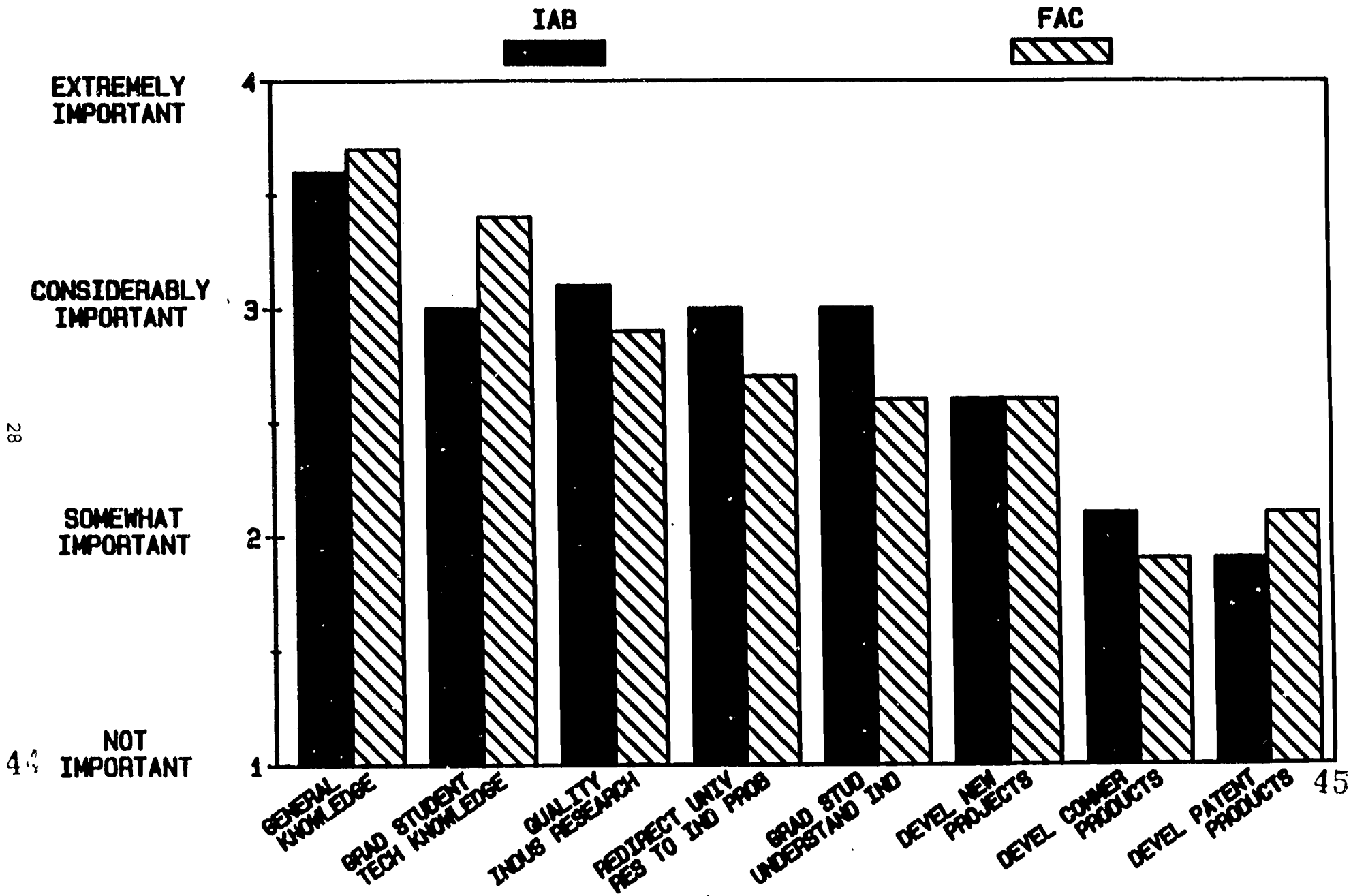
| | | | | |
|---|---|---|---|---|
| Development of patentable products in your firm | 1.93 (.896) | 2.12 (.882) | 8 | 7 |
| Development of commercialized products in your firm | 2.14 (1.115) | 1.86 (.833) | 7 | 8 |

* Scale: 1 = Not at all important; 2 = Somewhat important; 3 = Considerably important; 4 = Extremely important

[1] $t = 3.35$, $p < .001$
[2] $t = 3.05$, $p < .01$
[3] $t = 2.66$, $p < .01$

# FIGURE 3

## Faculty And Industry Respondents Scale



Although three goals were given significantly different ratings by the two groups, these differences seem minor and appear to reflect the different missions of industry and university.

Thus, faculty and industry were in virtual agreement about the most important and least important goals of a Center but differed somewhat about the relative importance of various intermediate goals.

Outcomes: Expected Benefits

Industry respondents. (Table 9) Industry respondents were asked to rate the likelihood that they would realize certain benefits from participation in the Center. The benefits seen as most likely to accrue to companies were improved research projects in the company (mean, 2.60; 1 = scarcely likely, 4 = almost certain) and better personnel recruitment (mean, 2.54). Patentable products (1.62) and commercialized products (1.75) were seen as benefits which were "somewhat" to "scarcely likely" to accrue through Center participation.

Faculty respondents. (Table 10) Faculty respondents were asked to rate the likelihood that the university would receive certain benefits from Center participation. The benefit seen as most likely to be realized by the university was "improved knowledge base" (mean, 3.78), followed by better student placement (mean, 3.39) and better student recruitment (mean, 3.23). At least half of the faculty respondents saw each of these benefits as being almost certain. Based on mean scores the next most likely benefits were: "increased funds for research from private sources" (3.11), "improved research projects in the university" (3.05), "better faculty recruitment" (2.78), "increased research funds from public sources" (2.58) and "increased university patent activity" (2.52).

Summary. Industry and faculty respondents were asked to rate the likelihood of different sets of benefits; hence, direct comparisons are not possible. For the industry respondents, the indirect benefits of improved research projects and better personnel recruitment were seen as the most likely benefits. Consistent with goal ratings, direct patent and product benefits were seen as scarcely likely. Faculty respondents also saw the indirect benefits as being the most likely to be realized by the university (improved knowledge base), but also saw some more concrete benefits, particularly student placement and recruitment and increased funding from private sources, as likely outcomes of participation in the Center.

Outcomes: Changes in Science

Industry respondents. (Table 11) Industry respondents were asked to indicate the extent to which their own R&D had been influenced by participation in the Centers. On the average, participation in Centers had little effect on R&D structures and methods in the companies. The area of greatest change was in "research topics and issues," with 23.8% of respondents indicating "some" or "a lot" of change, 31.0% reporting "a little" change and 45.2% reporting "hardly any" change. Over 60%

TABLE 9

INDUSTRY RESPONDENTS
OUTCOMES:
EXPECTED BENEFITS

How likely is it that your company will realize tangible benefits in the following areas as a result of your participation in the Center?

| | Mean | 4 Almost Certain % | 3 Pretty Likely % | 2 Somewhat Likely % | 1 Scarcely Likely % | N |
|---|---|---|---|---|---|---|
| Better personnel recruitment | 2.54 | 19.8 | 32.8 | 29.0 | 18.3 | 131 |
| Improved research projects in your company | 2.60 | 13.7 | 40.5 | 38.2 | 7.6 | 131 |
| Patentable products | 1.62 | 3.1 | 9.3 | 34.1 | 53.5 | 129 |
| Commercialized products | 1.75 | 7.7 | 9.2 | 33.1 | 50.0 | 130 |

(Percents may not equal 100 due to rounding error.)

TABLE 10

FACULTY RESPONDENTS
OUTCOMES:
EXPECTED BENEFITS

How likely is it that the university will realize tangible benefits in the following areas as a result of participation in the Center?

| | Mean | 4 Almost Certain % | 3 Pretty Likely % | 2 Somewhat Likely % | 1 Scarcely Likely % | N |
|---|---|---|---|---|---|---|
| Improved knowledge base | 3.78 | 82.8 | 12.5 | 4.7 | - | 64 |
| Better student recruitment | 3.23 | 53.1 | 21.9 | 20.3 | 4.7 | 64 |
| Better student placement | 3.39 | 50.0 | 40.6 | 7.8 | 1.6 | 64 |
| Better faculty recruitment | 2.78 | 28.1 | 34.4 | 25.0 | 12.5 | 64 |
| Improved research projects in the university | 3.05 | 37.5 | 37.5 | 17.2 | 7.8 | 64 |
| Increased funds for research from public sources | 2.58 | 17.2 | 34.4 | 37.5 | 10.9 | 64 |
| Increased funds for research from private sources | 3.11 | 34.4 | 45.3 | 17.2 | 3.1 | 64 |
| Increased university patent activity | 2.52 | 17.7 | 30.6 | 37.1 | 14.5 | 62 |

(Percents may not equal 100 due to rounding error.)

TABLE 11

INDUSTRY RESPONDENTS
OUTCOMES:
CHANGES IN R & D

To what extent has the research conducted at the Center caused changes in the R&D projects in your company?

| | Mean | 4 A Lot % | 3 Some % | 2 A little % | 1 Hardly any % | N |
|---|---|---|---|---|---|---|
| Research topics and issues | 1.81 | 2.4 | 21.4 | 31.0 | 45.2 | 126 |
| Research methods and procedures | 1.53 | 3.2 | 9.5 | 24.6 | 62.7 | 126 |
| Criteria and methods used to evaluate projects | 1.51 | .8 | 11.9 | 24.6 | 62.7 | 126 |

(Percents may not equal 100 due to rounding error.)

reported "hardly any" change in research methods or evaluation criteria. Using a scale of one ("hardly any") to four ("a lot"), the mean for changes in topics was 1.8, followed by methods and procedures (1.5) and evaluation methods and criteria (1.5).

Faculty respondents. (Table 12) Faculty were asked to rate how different Center projects were from the research they usually conduct. The aspect of Center research which was rated as being the most different was criteria and methods used to evaluate research projects, where 32.8% reported "a lot" of difference, 34.4% report "some" difference, 14.1% said "a little" difference, and 18.8% reported "hardly any" difference. More substantively, 64.1% of all respondents indicated that there was "some" difference between their Center research topics and issues (18.8% checked "a lot") and research projects typically conducted by them; 40.6% indicated "some" difference in their research methods and procedures (10.9% checked "a lot"). Thus, Center- sponsored research appears to represent at least a modest shift in topics and/or methodology for a substantial number of university participants. Using a scale of one to four, mean ratings of difference were: criteria used to evaluate projects (2.81), research topics and issues (2.62) and methods and procedures (2.12).

Summary. Not surprisingly, most industry respondents failed to report a lot of change in the R&D structure or methods at their firms as a result of Center participation. The area where there was the most change was in research topics and issues, a relatively indirect type of change. Faculty respondents reported that Center research was different from their usual research, particularly in the criteria and methods used to evaluate projects and to a lesser degree in their research topics and issues. While Centers did not radically change research-as-usual in either sector, it should be noted that approximately 24% of all industry respondents and 59% of all faculty respondents reported at least "some" change in their research topics and issues; and 12.7% of industrial respondents and 40.6% of faculty respondents reported some change in their research methods through Center participation. The impact of these changes on both academic and industrial research should be followed over time.

Outcomes: New Research

Industry respondents. (Table 13) Industry respondents reported on both new in-house and outside contract research generated by participation in the Center. In order to prevent the inflation of these estimates, multiple responses from a single company were averaged, unless one respondent indicated no new projects while another reported some activity. In these cases it was assumed that the one respondent (probably a monitor) was unaware of some new research activity and the non-zero answer was used.

A total of 68 new research projects were reported, for a mean of 8.5 new projects per Center and .72 new projects per company. These projects represent 4.13 million dollars, for a mean of $516.56 k per Center and $46.43 K per company. One company reported a one million dollar project; with this figure

TABLE 12

FACULTY RESPONDENTS
OUTCOMES:
DIFFERENCE IN RESEARCH

To what extent is the research conducted at the Center different from the research projects typically conducted by faculty associated with the Center?

| | Mean | 4 A Lot % | 3 Some % | 2 A little % | 1 Hardly any % | N |
|---|---|---|---|---|---|---|
| Research topics and issues | 2.62 | 18.8 | 45.3 | 15.6 | 20.3 | 64 |
| Research methods and procedures used | 2.12 | 10.9 | 29.7 | 20.3 | 39.1 | 64 |
| Criteria and methods used to evaluate research projects | 2.81 | 32.8 | 34.4 | 14.1 | 18.8 | 64 |

(Percents may not equal 100 due to rounding error.)

TABLE 13

INDUSTRY RESPONDENTS
OUTCOMES:
NEW RESEARCH

A. Approximately how many new research projects have been stimulated in your research laboratories by Center activities?

| Mean per Co. | Mean per Center | Total new projects |
|---|---|---|
| .72 | 8.5 | 68 |

How much is this in terms of research dollars?

| Mean per Co. | Mean per Center | Total research dollars |
|---|---|---|
| 46.43 K | 516.56 K | 4.132 mil. |

What percentage is this of your total R&D budget?

| Mean | Median | Std. Dev. |
|---|---|---|
| 1.8% | .12% | 5.74% |

In terms of person-years of full-time-equivalent staff?

| Mean | Median | Std. Dev. |
|---|---|---|
| 1.03 | .16 | 3.93 |

B. Has participation in Center activities stimulated other outside research contracts with faculty or another laboratory?

| | N | % |
|---|---|---|
| YES | 16 | 18.4 |
| NO | 71 | 81.6 |

If so, approximately how many research dollars?

| Mean per Co. | Mean per Center | Total research dollars |
|---|---|---|
| 60.4 K | 113.25 K | 906 K |

excluded, the averages are $391.5 K per Center and $29.8 K per company.

Approximately eighteen percent of companies reported that they had contracted additional outside research as a result of the Center. These contracts totalled $906 K, for a mean of $113.25 K per Center and $60.4 K per company on outside contracts.

Summary. Participation in the Centers appeared to be having an impact on the research agendas of participating companies. A total of $5.04 million in research projects, both in-house and in outside contracts, were generated as a result of Centers. Although there is no way of determining if this investment involved additional or reallocated research dollars, these investments help quantify the changes in research topics and issues reported above and may be the most tangible sign that technology transfer was occurring between university and industry.

Outcomes: Product and Process

Industry respondents. (Table 14) Industry respondents were asked to report if participation in the Center had any effect on ten possible product and process outcomes in their company. In general, industry respondents reported few such outcomes. Of the proposed product/process outcomes, only "Improved capability to cooperate with outside scientists" was a realized outcome for a sizeable number of companies (30%). Using a three-point scale (1 = No, 2 = Maybe, 3 = Yes), this was the only outcome with a mean of over 2 (2.1). "Improved product or process design" and "Improvements in processes and methods of production" had the next highest means, both at 1.6.

Faculty respondents. (Table 14) Faculty were asked to estimate the extent to which participating companies had realized these same outcomes. In terms of mean ratings, faculty consistently but nonsignificantly overestimated outcomes. However, the ranking of means was similar to industry responses (i.e., "Improved capability to cooperate with outside scientists" was the highest rated outcome (2.6), and "Improved product or process design" (2.0) and "Improvement in processes and methods of production" (2.1) were the next highest rated outcomes).

Industry/faculty comparison. Chi squares were significant for all ten outcomes, indicating different patterns of responses for faculty and industry. It appears that faculty respondents were more likely to indicate that outcomes had been realized.

Summary. Given the newness of most Centers, it is perhaps unrealistic to expect companies to have realized outcomes from their participation. Those outcomes that had been realized tend to be improved ability to cooperate with outside scientists and improvements in processes, rather than the product outcomes (new products or new product design). Given the areas of science in which some of these Centers are engaged, it is perhaps more realistic to expect process rather than product outcomes.

Faculty members tend to slightly overestimate both the indirect and direct product and process benefits of Center participation to companies.

TABLE 14

INDUSTRY AND FACULTY RESPONDENTS
OUTCOMES:
PRODUCT AND PROCESS

Has your participation in the Center had any effect on the following in your (sponsoring) company?

| | | Mean | 3 Yes | 2 Maybe | 1 No | Not Applicable | N |
|---|---|---|---|---|---|---|---|
| Improvements in products and services[1] | Industry | 1.5 | 9 | 20 | 49 | 29 | 107 |
| | Faculty | 2.0 | 10 | 25 | 11 | 6 | 52 |
| Changes in warranty and complaints in view of improvements in products[2] | Industry | 1.1 | 1 | 6 | 51 | 50 | 108 |
| | Faculty | 1.5 | 0 | 16 | 13 | 22 | 51 |
| New products developed due to related efforts[3] | Industry | 1.5 | 11 | 19 | 50 | 28 | 108 |
| | Faculty | 2.0 | 15 | 15 | 14 | 8 | 52 |
| Changes in cost of products to users (price changes or decreased product maintenance)[4] | Industry | 1.3 | 3 | 13 | 50 | 42 | 108 |
| | Faculty | 1.6 | 2 | 20 | 17 | 14 | 53 |
| Reduction of production costs[5] | Industry | 1.4 | 10 | 17 | 58 | 23 | 108 |
| | Faculty | 1.8 | 7 | 19 | 15 | 12 | 53 |
| Improvement in processes and methods of production[6] | Industry | 1.6 | 12 | 27 | 53 | 16 | 108 |
| | Faculty | 2.1 | 14 | 22 | 11 | 6 | 53 |
| Increased uniformity of products[7] | Industry | 1.3 | 4 | 19 | 57 | 28 | 108 |
| | Faculty | 1.8 | 5 | 20 | 14 | 14 | 53 |
| Improved product or process design[8] | Industry | 1.6 | 11 | 30 | 47 | 20 | 108. |
| | Faculty | 2.0 | 10 | 28 | 10 | 5 | 53 |

(continued)

Table 14 (cont.)

| | | Mean | 3 Yes | 2 Maybe | 1 No | Not Applicable | N |
|---|---|---|---|---|---|---|---|
| Improved capability to deal with government regulations[9] | Industry | 1.1 | 2 | 6 | 59 | 41 | 108 |
| | Faculty | 1.4 | 0 | 13 | 17 | 23 | 53 |
| Improved capability to cooperate with outside scientists[10] | Industry | 2.1 | 32 | 31 | 26 | 18 | 107 |
| | Faculty | 2.6 | 35 | 12 | 4 | 4 | 55 |

---

1 $x^2 = 23.58$, $p \leq .001$
2 $x^2 = 21.28$, $p \leq .001$
3 $x^2 = 14.65$, $p \leq .01$
4 $x^2 = 13.89$, $p \leq .01$
5 $x^2 = 12.04$, $p \leq .01$
6 $x^2 = 15.83$, $p \leq .01$
7 $x^2 = 13.66$, $p \leq .01$
8 $x^2 = 16.24$, $p \leq .01$
9 $x^2 = 15.95$, $p \leq .01$
10 $x^2 = 18.83$, $p \leq .001$

Outcomes: Personnel Exchange

Industry respondents. (Table 15) Industry respondents reported on a number of human resource transactions they had with the Center. There was a great deal of variability in the number of Center-trained students interviewed by companies. A grand total of 179 Center-trained students were interviewed by participating companies, with a mean of 22 per Center. A grand total of 27 students were hired, with a mean of 3.37 per Center.

Another form of human resource outcome is the exchange of personnel. There was a total of 39 site visits by company scientists to Centers, for a mean of 5 visits per Center. The total number of visits by Center scientists to industry labs was 80, for a mean of 10 per Center. The total number of scientists involved in these site visits can not be determined from the data. Since only 65 faculty are included in our respondent pool this must mean some faculty were responsible for multiple visits.

Summary. Centers are providing a pool of potential employees for companies, although only 15% of those interviewed were actually hired. Without knowing the overall hiring rates for these companies, it cannot be determined whether Center participation increases a student's likelihood of being hired by a member company or the likelihood a company will hire a Center student.

Scientific exchange of personnel between the two sectors did occur through Centers, with the bulk of this exchange being Center scientists going to visit companies. This appears to suggest that Center scientists are taking a more active role in the technology transfer than the industry scientists. Since the survey did not request information on the duration of these exchanges, there is no way of telling if these exchanges were brief visits or more substantial exchanges.

Outcomes: Career

Faculty respondents. (Table 16) Faculty were asked to estimate the extent to which participation in the Center influenced tenure, promotion or salary increases. The mean rating (1 = not at all, 4 = a great deal) was 2.54. Approximately seven percent (7.4%) of respondents indicated "a great deal," 48.1% said "a moderate amount", 35.2% said "a little", and 9.3% said "not at all."

Summary. The faculty's perceptions of the influence of Center participation on their careers indicate that participation per se is not important. Discussions with department heads and deans suggest that Center participation is judged by the traditional evaluation criteria of publications and quality graduate student research.

Outcomes: Evaluation

Industry respondents. (Table 17) Industry respondents evaluated the overall research program at their Center. The majority rated their Center's research program as "above

TABLE 15

INDUSTRY RESPONDENTS
PERSONNEL EXCHANGE

A. How many students trained in Center research projects have been interviewed for possible employment in your company?

| Mean per Co. | Mean per Center | Total Interviewed |
|---|---|---|
| 1.88 | 22.35 | 178.83* |

How many have actually been hired?

| Mean per Co. | Mean per Center | Total Hired |
|---|---|---|
| .30 | 3.37 | 27 |

B. How many scientists from your company have spent time working on-site at the Center?

| Mean per Co. | Mean per Center | Total |
|---|---|---|
| .42 | 4.87 | 39 |

How many university scientists from the Center have spent time working on-site in your company's labs?

| Mean per Co. | Mean per Center | Total |
|---|---|---|
| .80 | 10.1 | 80.5* |

*Fractions are a result of using means when there were multiple respondents from a single company.

## TABLE 16

### FACULTY RESPONDENTS
### OUTCOMES:
### CAREER

To what extent does faculty participation in the Center contribute to consideration for tenure, promotion, or salary increases?

| Mean | 4<br>A Great Deal | 3<br>A Moderate Amount | 2<br>A Little | 1<br>Not at all | N |
|---|---|---|---|---|---|
| 2.54 | 7.54% | 48.1% | 35.2% | 9.3% | 54 |

(Percents may not equal 100 due to rounding error.)

TABLE 17

INDUSTRY RESPONDENTS
OUTCOMES:
RATING OF RESEARCH

How would you rate the overall research program in the Center compared to similar research programs in other U. S. universities?

| | N | % |
|---|---|---|
| Top 2% (4) | 14 | 11.9 |
| Top 10% (3) | 39 | 33.0 |
| Above average (2) | 60 | 50.8 |
| Below average (1) | 4 | 3.4 |
| Not comparable | 1 | .8 |
| | 118 | 100 |
| Mean | 2.54 | |

(Percents may not equal 100 due to rounding error.)

average" (50.8%). Only 11.9% rated the program in the top 2%; 33% rated the program in the top 10%. A very small minority (3.39%) rated the research as "below average."

Industrial members had a generally high level of satisfaction with the overall operations and activities of the Center (Table 18). Seventy-six and one-half percent were considerably or completely satisfied. Only one respondent (.8%) checked "not at all satisfied". The mean satisfaction rating was 2.89 (1 = not at all, 4 = completely).

Satisfaction with specific aspects of the Center was also generally high, with Center administrative practices being the area of greatest satisfaction (mean, 3.07), followed by communications between the companies and Center staff (mean, 2.99), technical quality of the research (mean, 2.97), and responsiveness of the Center to industry needs (mean, 2.82).

Faculty respondents. (Table 18) Faculty were not asked to give a general satisfaction rating, but did rate their satisfaction in specific areas, using the same scale as industry respondents. The area of greatest satisfaction for faculty was the technical quality of the research (mean, 2.81), followed by responsiveness of the Center to industry needs (2.77), Center administrative practices (2.72) and communications between Center staff and the companies (2.51).

Industry/faculty comparison. (Tables 17 and 18; Figure 4) Across all four areas of satisfaction, industry respondents were more satisfied than faculty respondents. This difference was significant for satisfaction with communications between Center staff and companies ($t=4.23$, $p<.001$) and with Center administrative practices ($t=3.22$, $p<.01$).

Faculty were also asked to estimate industry's satisfaction with these same aspects of the Centers. Faculty correctly estimated industry as being more satisfied than they were themselves. These estimates were consistently but non-significantly lower than the satisfaction reported by industry respondents. The area of greatest disparity between faculty estimation and industry response was in the area of communications (2.66, faculty estimate; 2.99, industry response).

Summary. Both industry and faculty respondents were generally satisfied with the Centers. While industry respondents saw the Center research programs as being above average, few rated the research in the top 2%. Apparently, for most companies it is not essential that a Center be in a league by itself. However, it probably must be perceived as having a top 10% or better than average research program. In absolute terms, both industry and faculty participants seem quite satisfied with their Center. However, faculty respondents were somewhat less satisfied with all aspects of the Center than were industry respondents. They were significantly less satisfied with communications between Center staff and industry and with Center administrative practices. These differences may have been due to the fact that faculty, in contrast to industry representatives, were heavily involved in and consequently affected by Center operations.

TABLE 18

INDUSTRY AND FACULTY RESPONDENTS
OUTCOMES:
SATISFACTION

A. To what extent are you generally satisfied with the operations and activities of the Center? (Industry respondents)

| | N | % |
|---|---|---|
| Completely (4) | 18 | 13.6 |
| Considerably (3) | 83 | 62.9 |
| Some (2) | 30 | 22.7 |
| Not at all (1) | 1 | 0.8 |
| Total | 132 | 100 |
| Mean | 2.89 | |

B. To what extent are you satisfied with the following:

| | | Mean | 4 Completely | 3 Great Deal | 2 Some | 1 Not at All | N |
|---|---|---|---|---|---|---|---|
| Technical quality of research | Industry | 2.97 | 19.7 | 57.5 | 22.8 | 0 | 127 |
| | Faculty | 2.81 | 4.7 | 71.9 | 23.4 | 0 | 64 |
| | Faculty estimate | 2.86 | 10.2 | 66.1 | 23.7 | 0 | 59 |
| Communications Center staff/co.[1] | Industry | 2.99 | 25.8 | 48.4 | 25.0 | .8 | 128 |
| | Faculty | 2.51 | 6.2 | 46.2 | 40.0 | 7.7 | 65 |
| | Faculty estimate | 2.66 | 11.5 | 42.6 | 45.9 | 0 | 61 |
| Center administrative practices[2] | Industry | 3.07 | 27.9 | 52.5 | 18.9 | .8 | 122 |
| | Faculty | 2.72 | 13.8 | 46.2 | 38.5 | 1.5 | 65 |
| | Faculty estimate | 2.95 | 15.3 | 64.4 | 20.3 | 0 | 59 |

(continued)

Table 18 (cont.)

| | | Mean | 4 Completely | 3 Great Deal | 2 Some | 1 Not at All | N |
|---|---|---|---|---|---|---|---|
| Responsiveness of Center to industry | Industry | 2.82 | 17.6 | 50.4 | 28.0 | 4.0 | 125 |
| | Faculty | 2.77 | 11.3 | 56.5 | 30.6 | 1.5 | 62 |
| | Faculty estimate | 2.65 | 8.6 | 48.3 | 43.1 | 0 | 58 |

(Percents may not equal 100 due to rounding error.)

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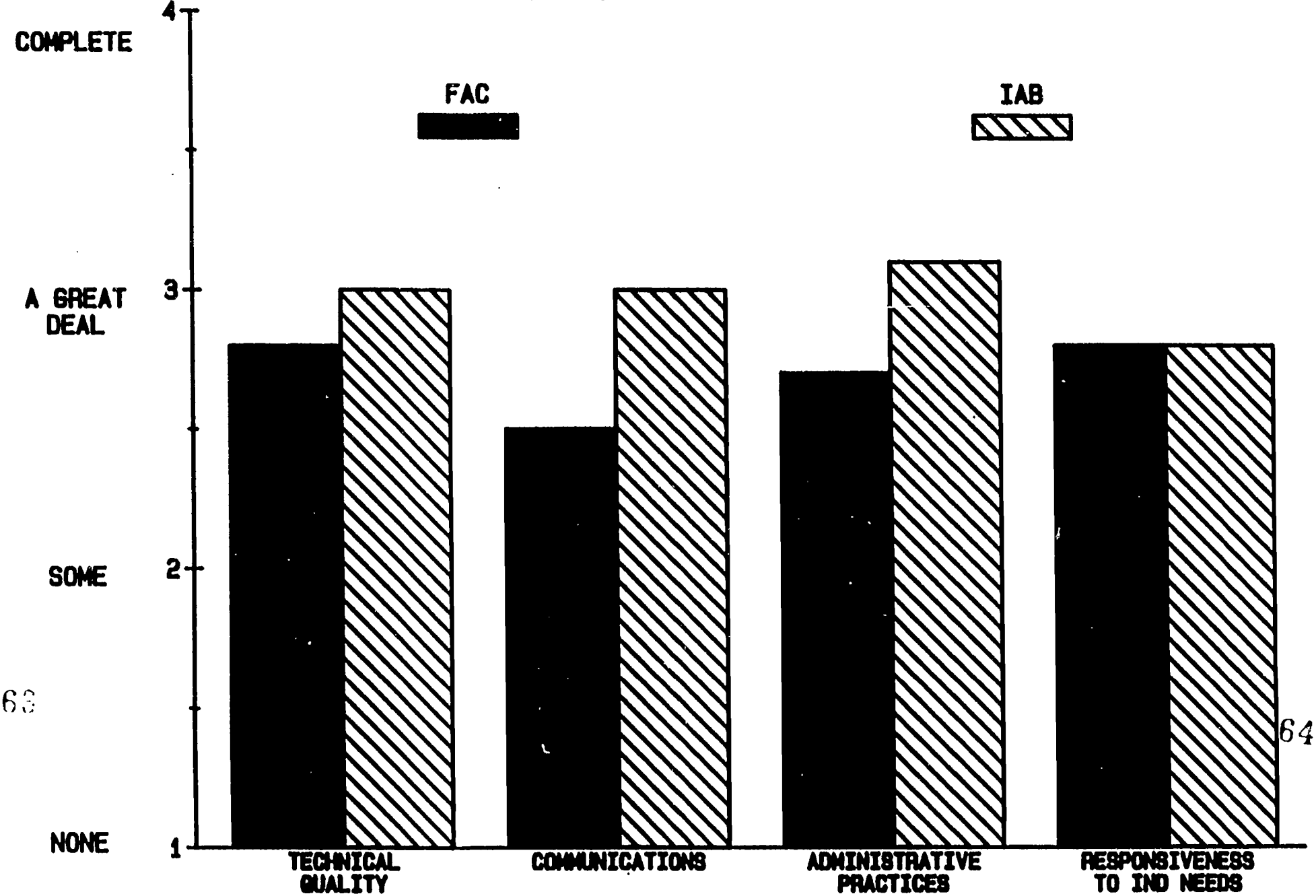
[1] $t=4.23$, $p \leq .001$ for industry vs. faculty.
[2] $t=3.22$, $p \leq .01$ for industry vs. faculty.

# FIGURE 4

## Faculty And Industry Respondents Outcomes: Satisfaction



# CHAPTER 3
# CORRELATIONAL ANALYSIS

This chapter presents the results of correlational analyses performed on the data described in Chapters 1 & 2. The purpose of these analyses was to explore relationships between respondent descriptors, prior contact/Center initiation, current operations, goals, and the outcome measures. The discussion is organized by data category. Again, although probabilities are not relevant with a population, correlations which are significant at alpha of .05 or below will be noted to help focus the discussion.

Prior to performing correlational analyses, it was necessary to reduce the number of variables in each data category. The first section will describe the data reduction strategy.

## DATA REDUCTION AND VARIABLE AGGREGATION

### Strategy

There were ninety-three discrete variables coded for industry respondents and eighty-six for faculty respondents. Data reduction and aggregation were performed for each set of respondents in order to reduce the number of variables under consideration and simplify subsequent analyses. Table 19 summarizes the results of the data reduction.

The first step in the process was the elimination of items with minimum variance or low response rates. Nine variables were eliminated from the industry data: number of requests for information, percent of the requests that were technical, percent of requests that were operational, changes in warranty, improved ability to cooperate with government regulations, the field in which the respondent had their degree, features of the Center with which the respondent was particularly satisfied or dissatisfied, and the specific nature of changes in company research as a result of Center participation. The latter four were open ended questions with low response rates; the former five had little variance (i.e., few requests for information were reported). Two variables were eliminated from the faculty data: the specific nature of differences between Center research and their usual research, and the number of outside groups with which the Center had significant contact. These were open-ended questions with low response rates.

Next, some recoding was performed to create rational mini-scales. Three such scales were created for the industry data. These were a count of the total number of Center planning activities in which the respondent was involved, the number of Center administrative activities in which the respondent was involved, and the number of different modes of prior contact between the company and Center-affiliated personnel. These are described further in the relevant sections below.

The remaining variables, including the mini-scale values, were grouped according to the conceptual domains previously described: 1) descriptors, 2) prior relationships/Center initiation, 3) current operations, 4) goals and 5) benefits and

TABLE 19

RESULTS OF DATA REDUCTION

A. INDUSTRY

| Data Category | No. of original variables | No. of variables after data reduction |
|---|---|---|
| 1. Respondent descriptors | 11 | 5 |
| 2. Prior contact/Center initiation | 16 | 6 |
| 3. Current operations | 21 | 9 |
| 4. Goals | 8 | 4 |
| 5. Benefits & outcomes | 37 | 9 |
| | 93 | 33 |

B. FACULTY

| | | |
|---|---|---|
| 1. Respondent descriptors | 2 | 2 |
| 2. Prior contact/Center initiation | 6 | 6 |
| 3. Current operations | 3 | 2 |
| 4. Goals | 8 | 2 |
| 5. Benefits & outcomes | 31 | 7 |
| 6. Influence | 36 | 4 |
| | 86 | 23 |

outcomes. Principal components factor analyses with oblique rotations were performed within each of these domains. Industry and faculty data sets were analyzed separately. Extracted factors were inspected for conceptual coherence, and factors with eigenvalues of 1.0 were retained. Variables with factor loadings of .4 or greater were given a weight of one; all other variables were weighted zero. Appendix D provides more detail on the factor analyses.

Since several different rating scales were used in the survey, all variables were converted to Z scores and the resulting values summed and divided by the number of variables to create composite variables. A composite variable was coded as missing for a respondent if more than 30% of the component items were missing.

For industry respondents the total number of variables was reduced from 93 to 33. For university respondents the total number of variables was reduced from 56 to 23.

## Results

The following sections describe the results of the data reduction and the Pearson correlations among variables within each domain.

### Respondent Descriptors

Industry Respondents. For industry respondents, data reduction resulted in four discrete variables and one composite variable. The composite variable, a measure of seniority, includes number of years in industry, years in R&D, years in company, and years in R&D in company. The four discrete variables are number of levels between respondent and the chief executive officer, number of people reporting directly to the respondent, number of people reporting through others, and the highest degree held by the respondent.

Table 20 presents the correlations among these variables. The statistically significant correlations are logical but unremarkable: the number reporting through others correlates negatively with levels to chief executive officer ($-.23$, $p \leq .01$) and positively with the number reporting directly ($.27$, $p \leq .001$).

Faculty Respondents. For faculty respondents two discrete variables were included in this category: academic rank and tenure status. The variables were positively but not significantly correlated (Table 20).

### Prior Relationships/Center Initiation

Industry Respondents. For industry respondents, six variables remained after factor analysis. Four of these are discrete variables: whether or not the respondent received a degree from the Center university, the frequency of prior contact with Center personnel, the number of organizational levels which had to approve joining the Center, and the number of individuals at the respondent's level who had to concur with the decision to join. The other two variables in this domain are mini-scales. The

TABLE 20

CORRELATIONS AMONG RESPONDENT DESCRIPTORS

| A. INDUSTRY | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Seniority | | | | |
| 2. Levels to CEO | -.04 | | | |
| 3. Number reporting directly | .04 | -.06 | | |
| 4. Number reporting through others | .14 | -.23* | .27** | |
| 5. Highest degree held | -.03 | .03 | .01 | -.10 |

| B. FACULTY | 1 | 2 |
|---|---|---|
| 1. Academic rank | | |
| 2. Tenure status | .16 | |

*$p \leq .01$
**$p \leq .001$

"modes of prior contact" scale is a count of the total number of modes of prior contact with Center personnel (i.e., consulting, contract research, faculty exchange, student exchange, general support of faculty research, support of student research, other). The "planning activities" scale is comprised of the total number of types of Center planning activities in which the respondent was involved (i.e., planning, recruitment of new member companies, organizing meetings, proposal writing, building support within the university, other).

The correlations among these variables are presented in Table 21. Having a degree from the Center university is significantly correlated with the prior contact scale (.21, $p \leq .01$); frequency of prior contact (.31, $p \leq .001$); and the planning activities scale (.31, $p \leq .001$). Frequency of prior contact was significantly correlated with the planning activities scale (.32, $p \leq .001$). The modes of prior contact scale was correlated with frequency of prior contact (.30, $p \leq .001$) and the planning activities scale (.36, $p \leq .001$). None of the variables in this domain were significantly correlated with the number of individuals at the same level who had to concur with joining or the number of organizational levels that had to approve membership although these two variables were significantly intercorrelated (.28, $p \leq .001$).

There two things of note within this pattern of correlations. First, the findings indicate that those who had been students at the Center university or had more prior involvement with the university in other capacities, tended to be more involved with Center planning. To the extent that such involvement is necessary and helpful, Centers may need to attract firms which employ alumni as early supporters. It also suggests a bureaucratic or collective decision-making relationship in the membership decision-making process. If one needs a large number of people at their level to concur in the membership decision, they probably will also need to get more levels of the company to give approval. Possibly in these instances, the initiative to join a Center came from a lower organizational level or perhaps the organization is simply more bureaucratic. It would be interesting to have comparable data from firms which decided not to join a Center.

Faculty Respondents. For faculty, six discrete variables were included in the prior relationships category: prior consulting, prior contract research, prior faculty exchange, prior student exchange, and "other" types of prior contact with member companies. Table 21 presents the correlations among these variables. The only significant correlations were between "other" types of prior contact and prior consulting (-.51, $p \leq .001$) and between "other" types and prior contract research (-.36, $p \leq .01$). Thus, faculty who were involved with industry in "other" types of interactions tended not to be involved in consulting or contract research and vice versa.

Current Operations

Industry Respondents. Nine variables (one composite, eight discrete) are included in this domain for industry respondents.

TABLE 21

CORRELATIONS AMONG
PRIOR RELATIONSHIPS/CENTER INITIATION VARIABLES

| A. INDUSTRY | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Degree from Center university | | | | | |
| 2. Number of types of prior organizational contact | .21* | | | | |
| 3. Frequency of prior contact | .31** | .30** | | | |
| 4. Number of Center planning activities individual involved in | .31** | .36** | .32** | | |
| 5. Number of organizational levels to approve joining Center | -.02 | -.07 | -.10 | -.08 | |
| 6. Number of individuals at the same level who had to concur | -.05 | .00 | -.07 | -.04 | .28** |

| B. FACULTY | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Prior consulting | | | | | |
| 2. Prior contract research | -.27 | | | | |
| 3. Prior faculty exchange | -.16 | -.11 | | | |
| 4. Prior student exchange | -.09 | -.15 | -.03 | | |
| 5. Other types prior contact | -.51** | -.36* | -.05 | .02 | |
| 6. Frequency of prior contact | .03 | .20 | .07 | -.16 | -.07 |

* $p \leq .01$
** $p \leq .001$

The composite variable includes involvement of Divisional R&D and the number of Center administrative activities in which the respondent is involved. The eight discrete variables are total additional cost of Center participation beyond annual fees (a mini-scale derived by summing the costs of space, time, travel and other), involvement of Central R&D, involvement of Marketing group, involvement of Engineering/technical group, involvement of Corporate planning group, involvement of Production group, involvement of other groups, and extent to which top management is involved in the Center.

The correlations are displayed in Table 22. The extent of Divisional R&D involvement is significantly correlated with Engineering/technical group involvement (.16, $p \leq .01$). Engineering/technical involvement is significantly correlated with Production group involvement (.24, $p \leq .01$). Central R&D involvement is significantly negatively correlated with Engineering/technical involvement (-.30, $p \leq .01$). Involvement of Marketing groups is significantly correlated with involvement of Corporate planning (.18, $p \leq .01$) and the extent of top management involvement (.33, $p \leq .001$). Involvement of Corporate planning and extent of top management involvement are significantly correlated (.22, $p \leq .01$).

It is not clear why Divisional R&D involvement and the respondent's involvement in Center administrative activities constitute a factor. However, the other significant correlations suggest that three substantially different profiles of Center-corporate interaction tend to occur. These patterns of interaction are displayed in Figure 5. First, involvement of Central R&D with a Center has no relationship to the involvement of other industrial groups except Engineering/technical. However, if Central R&D is regularly involved with a Center, Engineering/technical group involvement is unlikely. A Central R&D- Center relationship may be likened to two universities interacting and may produce more knowledge transfer and less technology transfer. This pattern reinforces the stereotype of Central R&D as isolated from other corporate functions.

In contrast, if a Center is regularly involved with Divisional R&D it tends to interact with other groups within the company. The more regularly Divisional R&D is involved in a Center, the more regularly Engineering/technical groups interact with the Center. The more regular Engineering/technical involvement, the more regular involvement with Production groups. These relationships seem to mirror the R&D process from research to development to production.

Another special case seems to occur when there is top management involvement. If top management is involved regularly in a Center, then it is more likely that corporate planning and marketing are involved, suggesting the final stages of product or process development.

While these interpretations of these relationships are preliminary, they may be instructive for university and corporate strategists who want to manage and optimize the contact points for their interactions.

Faculty Respondents. For faculty respondents, there were two discrete variables and four composites within this domain. The

TABLE 22

CORRELATIONS AMONG CURRENT OPERATIONS VARIABLES

| A. INDUSTRY | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1. Involvement of respondent in Center activities/involvement of Divisional R&D. | | | | | | | | |
| 2. Total cost above yearly fees | .10 | | | | | | | |
| 3. Central R&D involvement | .06 | .04 | | | | | | |
| 4. Marketing involvement | .01 | .16 | -.06 | | | | | |
| 5. Engineering/technical involvement | .16* | .05 | -.30** | -.02 | | | | |
| 6. Corporate planning involvement | -.01 | -.02 | .07 | .18* | .07 | | | |
| 7. Production involvement | .03 | -.02 | .03 | .04 | .24* | .10 | | |
| 8. Other group involvement | -.14 | .02 | -.13 | -.08 | .00 | -.08 | .01 | |
| 9. Extent of top management involvement | .14 | .09 | .08 | .33** | .15 | .22* | .14 | .0 |

(continued)

Table 22 (cont.)

| B. FACULTY | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Number of projects | | | | | |
| 2. Percent time on Center projects | .25* | | | | |
| 3. Industrial advisory board/Center director influence | .33* | .09 | | | |
| 4. Faculty influence | .38* | .14 | .19 | | |
| 5. University policy/ administration influence | .21 | .02 | .37* | .26 | |
| 6. Student influence | .29 | .11 | .38* | .29 | .31* |

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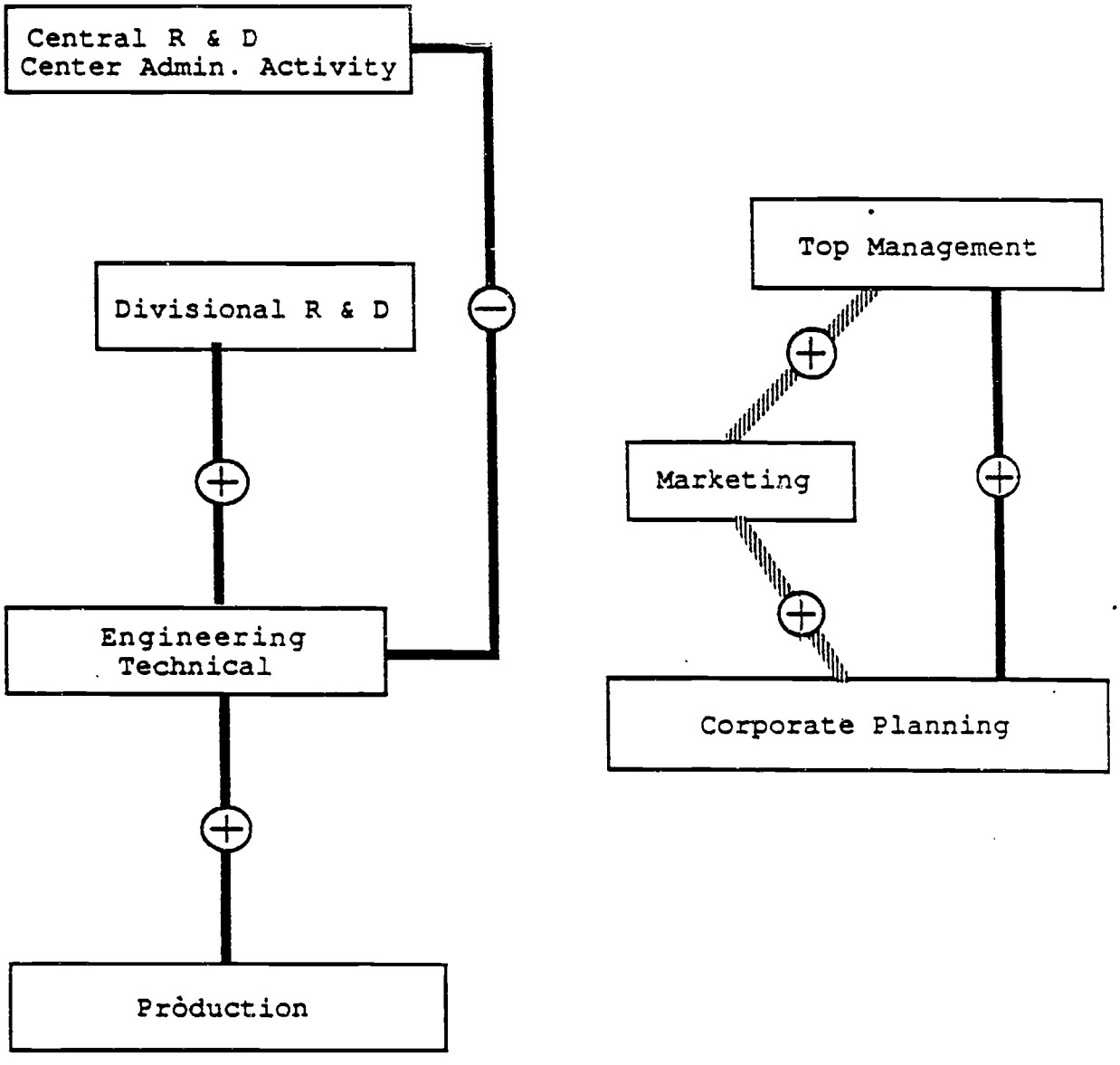
* $p \leq .01$
** $p \leq .001$

# FIGURE 5

## Industry Involvement In Center Operations



discrete variables both reflect the level of involvement in the Center, i.e., the number of projects in which the respondent is involved and the percent of the respondent's time spent on Center projects. The composites are composed of items which reflected faculty's estimates of the influence of various groups or forces on six different aspects of Center operations. Although not completely uniform, the composites reflect center director and Industrial Advisory Board influence, faculty influence, university administration and procedures influence, and student influence.

Correlations among the variables in this domain are presented in Table 23. Although they did not form a factor, the number of projects in which respondents are involved is significantly correlated with percent time spent on Center projects (.25, $p \leq .01$). Number of projects is also significantly correlated with a perception of Industrial Advisory Board and director influence (.33, $p \leq .01$) and faculty influence (.38, $p \leq .01$). Perception of director/board influence is significantly correlated with a perception of university administration and procedure influence (.37, $p \leq .01$) and student influence (.38, $p \leq .01$). Student influence is significantly correlated with university administration and procedure influence (.31, $p \leq .01$).

The pattern of intercorrelations observed here do not appear to lend themselves to a clear or cogent interpretation. They suggest that faculty who are more involved with Center research perceive the influence of the industrial advisory board and the director to be greater and also feel that they have more influence than those who are less involved.

Goals

Industry Respondents. For industry respondents, factor analysis resulted in two discrete variables and two composite variables. The composite variables are "technical goal importance" (improved quality of industrial research, development of new research projects in the company, development of patentable projects and development of commercialized products); and "training goal importance" (enhancement of graduate students' understanding of industry and enhancement of graduate students' technical training.) The two discrete variables are expansion of general knowledge, and redirection of university research toward industrial problems.

Table 23 displays the correlations among these variables. Although knowledge expansion and redirection of university research toward industrial problems are not included in the two goal factors, expansion of general knowledge is significantly correlated with training goal importance (.18, $p \leq .01$), and redirection of university research is significantly correlated with technical goal importance (.31, $p \leq .001$).

Faculty Respondents. For faculty respondents, factor analysis resulted in two composite variables which contain all goal variables. A training factor was identical to this factor for industry respondents but also included expansion of general knowledge. The technical factor included all the variables in the industry technical factor, plus redirection of university

TABLE 23

CORRELATIONS AMONG GOALS

| A. INDUSTRY | 1 | 2 | 3 |
|---|---|---|---|
| 1. Technical goals | | | |
| 2. Training goals | -.08 | | |
| 3. General expansion of knowledge | .14 | .18* | |
| 4. Redirection of university research | .31** | .06 | .03 |

| B. FACULTY | 1 | 2 |
|---|---|---|
| 1. Technical goals | | |
| 2. Training goals | .33* | |

---

* $p \leq .01$
** $p \leq .001$

research toward industrial problems. As seen in Table 22, the two variables are significantly correlated with each other (.33, $p \leq .01$).

These findings suggest subtle differences between industry and faculty perceptions of Center goal importance. For industry, general knowledge expansion and redirection of university research toward industrial problems are perceived as separate from, but significantly correlated with, the training goals and technical goals composite variables, respectively. For faculty, these variables are part of the two composite variables. More importantly, industry perceptions of the importance of training goals (including the general knowledge expansion variable) and technical goals (including the "redirection of university research" variable) are uncorrelated. By contrast, faculty who perceive one factor as important also perceive the other to be important, indicating less of a tendency among faculty to compartmentalize Center goals.

Outcomes

Industry Respondents. For industry respondents data reduction resulted in five composite variables and four discrete variables. The five composites represent: 1. investments in new research/realized process outcomes; 2. satisfaction/expected indirect benefits; 3. expected product outcomes/high percent of respondent's R&D budget in Center stimulated research; 4. changes in research methods; and 5. personnel exchange. The four discrete variables are the awarding of new outside research contracts, the dollar value of those contracts, the number of students interviewed and the number of students hired.

Table 24 presents the correlations among outcome variables. Investments in new research/realized process outcomes is significantly correlated with changes in research methods (.31, $p \leq .01$) and with expected product outcomes (.48, $p \leq .001$). Satisfaction/expected indirect benefits is significantly correlated with changes in research methods (.25, $p \leq .01$) and with expected product outcomes (.30, $p \leq .001$). Personnel exchange is significantly correlated with the number of students hired (.28, $p \leq .01$). Number of students interviewed is correlated (reasonably enough!) with number of students hired (.40, $p \leq .001$).

This pattern of correlations suggests that investments in new research/realized processes are related to both the expectation of positive outcomes and changes in the ways research is conducted; one could plausibly argue causality in either direction. Instances of direct contact between Center and company scientists in the form of personnel exchange are related to the number of students hired, suggesting that the opportunity to view students at work leads to a greater likelihood of hiring them.

Faculty Respondents. For faculty respondents, factor analysis resulted in five composite variables and two discrete variables. The five composite variables represent: 1. the perceived likelihood of university benefits, 2. reported changes in research, 3. satisfaction, 4. estimated industry satisfaction, and 5. estimated industry outcomes. The discrete

TABLE 24

CORRELATIONS AMONG OUTCOME VARIABLES

| A. INDUSTRY | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1. New research and realized process outcomes | | | | | | | | |
| 2. Satisfaction and expected benefits | .23 | | | | | | | |
| 3. Changes in research | .31* | .25* | | | | | | |
| 4. Expectations of product outcomes | .48** | .30** | .18 | | | | | |
| 5. Personnel exchange | .23 | .15 | .01 | .05 | | | | |
| 6. Outside research contracts | -.03 | .07 | .17 | -.08 | .05 | | | |
| 7. Outside research dollars | .33 | -.28 | .05 | -.07 | .48 | a | | |
| 8. Students interviewed | -.07 | .11 | -.09 | -.13 | .07 | .08 | .16 | |
| 9. Students hired | -.09 | .11 | -.04 | .02 | .28* | .01 | -.06 | .40* |

(continued)

Table 24 (cont.)

| B. FACULTY | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. Perceived likelihood of university benefits | | | | | | |
| 2. Changes in research | .10 | | | | | |
| 3. Satisfaction | .32* | .12 | | | | |
| 4. Estimated industry product and process outcomes | .33 | -.09 | .33 | | | |
| 5. Estimated industry satisfaction | -.19 | -.13 | .45** | .20 | | |
| 6. Perceived industry ability to cooperate with outside scientists | .32* | .14 | .15 | .02 | -.05 | |
| 7. Perceived likelihood of university patent activity | .36* | .09 | .07 | .46* | -.17 | .23 |

---

* $p \leq .01$
** $p \leq .001$

[a] Coefficient could not be computed due to sample size.

variables are the perceived likelihood of increased university patent activity and a perception of industry's increased ability to cooperate with outside scientists.

Correlations among faculty outcome variables are presented in Table 24. The perceived likelihood of university benefits is significantly correlated with satisfaction (.32, $p \leq .01$), with the extent to which respondents believe the Center has influenced industry's ability to cooperate with outside scientists (.32, $p \leq .01$) and with an expected increase in university patent activity (.46, $p \leq .01$). The interpretation of these correlations is that they reflect a generally positive attitude toward the Center; i.e., general satisfaction is resulting in a "halo effect." Alternatively, perceptions of university outcomes being likely may result in satisfaction. Longitudinal data now being collected will aid in interpreting these relationships.

Faculty satisfaction is significantly correlated with estimated industry satisfaction (.45, $p \leq .001$). Estimated industry outcomes is significantly correlated with the expectation of increased university patent activity (.46, $p \leq .01$). This correlation suggests that there is a relationship between how applied (patentable) the Center research is and the extent to which faculty perceive that companies realize benefits from participation.

Unfortunately, most of the outcome variables for faculty are subjective estimates of satisfaction and the likelihood of certain benefits. Thus, most of these findings are probably influenced by general optimism/satisfaction. Interestingly, reports of "differences in research", probably the most concrete variable in this group, does not correlate significantly with any of the other variables.

## Correlations of Outcomes With Descriptors, Prior Relationships, Current Operations and Goals

In order to determine if respondent descriptors, prior relationships, current operations and goals help explain any of the variance in outcomes, Pearson correlations were computed between variables and scales in these domains and the outcome composites/variables. Tables 25 and 26 present the significant correlations ($p \leq .01$) from these analyses.

Industry Respondents. (Table 25) None of the variables or composites examined correlated significantly with outcomes of satisfaction/expected benefits, changes in research, outside research contracts, outside research dollars, or students hired.

For industry respondents, three variables were correlated with investments in new research/realized process outcomes: seniority (-.25, $p \leq .01$); and the importance attached to goals of redirecting university research toward industry problems (.29, $p \leq .01$); and technical goals (.28, $p \leq .01$). Thus, we find that industrial participants who attach more importance to technical goals for the Center and to redirecting university research toward industrial problems are also reporting additional investments in Center-stimulated research and realized process outcomes. Apparently, seeing importance in the technical or

TABLE 25

INDUSTRY RESPONDENTS
CORRELATIONS BETWEEN "PREDICTOR" AND OUTCOME MEASURES

| | Investments in new research/ realized process outcomes | Satisfaction/ expected benefits | Changes in research | Expected product outcomes | Personnel exchange | Outside research contracts | Outside research dollars | Students interviewed | Students hired |
|---|---|---|---|---|---|---|---|---|---|
| Respondent descriptors | Seniority -.25* | | | Seniority -.22* Ievels to CEO -.33** | | | | | |
| Prior contact/ Center initiation | | | | | | | | | |
| Current operations | | | | Involvement of marketing staff .38** Involvement of top mgmt. .54** | Involvement of Central R&D .23* | | | | |
| Goals | Redirection of university research .29* Technical goals .28* | | | Technical goals .42** | | | | Training goals .29** | |

*p ≤.01
**p ≤.001

TABLE 26

FACULTY RESPONDENTS

CORRELATIONS BETWEEN "PREDICTOR" AND OUTCOME MEASURES

| | | Perceived likelihood of university benefits | Changes in research | Satisfaction | Estimated industry product & process outcome | Estimated industry satisfaction | Perceptions of industry ability to cooperate | Perceived likelihood of increased university patent activity |
|---|---|---|---|---|---|---|---|---|
| Respondent descriptors | | | | | | | | |
| Prior contact/ Center initiation | Prior consulting -.33* | | | | | | | |
| Current operations | Number of projects in which involved .29* | | | | | | | |
| Influence | Influence of university administration/ policy .38* | Influence of students -.30* | | | | | | |
| GOals | Technical goals .33* | | | | | | Training goals .35* | Technical goals .42** |

*p ≤ .01
**p ≤ .001

development goals of a Center "predicts" subsequent research investments and process results. Interestingly, having less senior board members also "predicts" these outcomes.

Possible explanations for this finding include: less senior people may feel more pressure to show some results from the Center and become more aggressive in translating Center research into such outcomes; they may be more forthcoming in reporting such outcomes; the involvement of less senior people as board members may lead to realized and expected outcomes by virtue of their greater involvement in research activities (freedom from administrative burdens within their companies); or less senior people may be more aware of and more likely to report "smaller" outcomes than are higher level people.

Five variables were associated with expected product outcomes: seniority (-.22, $p \leq .01$); levels to CEO (-.33, $p \leq .001$); involvement of marketing staff (.38, $p \leq .001$); involvement of top management (.54, $p \leq .001$) and technical goals (.42, $p \leq .001$). Again, less senior people may report greater expectations of outcomes for some of the reasons discussed above. Interestingly, respondents who are higher up in the organization (fewer levels from the CEO) also have higher expectations. The other correlations are reasonable but unlikely to be causal. In other words, it is probably more likely that these groups would become involved when and if new products were expected to be developed than that their involvement resulted in this expectation.

One variable, involvement of Central R&D (.23, $p \leq .01$), was associated with personnel exchange, suggesting that personnel exchange is more likely to occur between the industry group focused on basic research, Central R&D, than with other, more development-oriented groups.

The importance attached to training goals was the only variable associated with students interviewed (.29, $p \leq .001$). Those companies that rate training goals more highly probably have a greater need for personnel and are more active in interviewing students.

As mentioned above, none of the prior contact/Center initiation variables were significantly correlated with outcomes, suggesting that member companies do not have to be part of an "old boy network" in order to benefit from Center participation.

Faculty Respondents. (Table 26) For faculty respondents, none of the variables or composites examined correlated significantly with satisfaction, estimated industry product and process outcomes, and estimated industry satisfaction. In addition, none of the respondent descriptors was significantly correlated with outcomes.

Four variables were associated with the perceived likelihood of university benefits: prior consulting (-.33, $p \leq .01$); number of projects in which the respondent is involved (.29, $p \leq .01$); the perceived influence of university administration/university policy on Center operations (.38, $p \leq .01$); and technical goals (.33, $p \leq .01$).

The negative correlation between prior consulting and the perceived likelihood of the university realizing benefits from the cooperation is somewhat puzzling. Possibly, individuals who have more industrial experience (through consulting) are more

skeptical about the likelihood of the university deriving benefits from the Center or perhaps they do not differentiate between that experience and their experience with the Center. In contrast, those who are more involved in Center research see greater potential benefits; causality in either direction is equally plausible.

Not surprisingly, the more influence one perceives the university administration and policy to have on Center operations, the more likely one is to believe that the university will derive benefits from the Center. Interestingly, individuals who see the technical goals of the Center as being important are also more likely to anticipate university benefits. These individuals may believe a more technically oriented Center will help the university in the specific areas that make up this cluster, i.e., improve faculty recruiting, student placement, etc. These same individuals also perceive a high likelihood of increased university patent activity. The influence of students on Center operations is negatively correlated with changes in research. This appears to imply that student influence works against changes in research. When student influence is strong, faculty may avoid or resist making changes in their research topics and methods.

Individuals who attach importance to the Center's training goals believe that industry has improved its ability to cooperate with outside scientists -- virtually the only non-technical benefit listed in the questionnaire for industry.

# CHAPTER 4
# SUMMARY AND CONCLUSIONS

At the time this report was completed, a total of 29 Centers had been created, four Centers were already self-sufficient, and it was anticipated that approximately ten more Centers would be started during the next fiscal year. There is also evidence that a large number of other "centers", stimulated by the IUCRC Program, have been created in recent years by state governments and universities. Thus, by some standards NSF's IUCRC Program can be considered a major succcess story among Federal science and technology inititives.

Yet, in spite of the success of the IUCRC Program, we knew very little about these novel organizations. Macro-organizational information was available on Centers: their institutional location, scientific focus, staffing patterns, budgets, and the fact that they primarily involved large companies and major research universities. However, organizations, particularly complex boundary-spanning organizations like Centers, are difficult to truly comprehend at a macro-organizational level. Centers typically involve no dedicated facilities and have few if any staff of their own. Instead, they involve structured give and take between the representatives of two sectors of society, industry and universities.

In order to meaningfully understand these organizations we need to view them at a micro-organizational level and, ideally, through the eyes of their participants. For instance, in order to understand what Centers are and what holds them together we need to know who is participating in them; why they are participating; their level of involvement; what they and their employers expect to get out of their participation; their perceptions of and reactions to the organizational structure, policies and procedures we have come to label an Industry-University Cooperative Research Center; the relationship between structures and processes and various outcomes, etc. While many questions about Centers remain to be answered, this study and the other components of the Centers evaluation sheds considerable light on these and other issues.

It is our hope that a better, more refined understanding of Centers will help government, university, and industry policy makers and administrators improve the operation of existing Centers and inform efforts to build similar organizations. However, a comprehensive cataloging of the implications of these findings is beyond the scope of this report. Instead, below, we attempt a brief and global distillation of the implications of our findings for Centers and discuss issues/questions which may need to be addressed in analyses of future evaluation data sets or in other studies. Since the study findings are summarized in the Executive Summary of this report, we will not attempt to repeat them here. Readers who are interested in such a review should refer to this section in the beginning of this document.

## CONCLUSIONS

The literature on industry-university cooperation frequently reads more like the literature on "industry-university antagonism". Journal articles and book chapters too numerous to mention have documented the variety of barriers to meaningful cooperation, the reasons for the estrangement between the two sectors and the forces which conspire against a reconciliation. Our findings provide persuasive evidence that these barriers can be overcome within the context of a Center. Surprisingly, in many cases Centers are uniting firms and university scientists who have never collaborated before.

Reports from the two major stakeholder groups involved in Centers (university faculty and industrial board members) paint a very positive picture of the interactions taking place between them. Both groups appear to attach essentially the same degree of importance to a variety of goals; they appear to hold modest and quite attainable expectations about the benefits their participation might produce; and they seem highly satisfied with their Centers and their participation in them. However, it should be noted that in the course of forging their partnership both parties have made major concessions. Within the context of a Center, member firms have agreed to cooperatively fund an essentially basic research program -- major departures for most companies. For their part, faculty recognize that they do share project selection and evaluation influence with the Center Director and the Industrial Advisory Board. Reassuringly, however, they also perceive themselves as essentially masters of their own scientific fate; they have maintained control over the actual conduct of their research.

It should be noted that some of our findings provide news that will be disappointing to those who hoped Centers would act as a catalyst for increased industry-university interaction. Consistent with the results from the network analysis of Center communication patterns (Eveland, 1985), these findings reveal a relatively low level of participation by industrial representatives in both initiating the Center and, later, in the daily operations. In addition, relatively few companies send their own scientists to spend time at the Center, although a good many university scientists report spending time at firms. The low level of industrial involvement in Centers may be a source of concern and may account for faculty's significantly lower satisfaction with communications between industry and Center personnel. These findings suggest that university-industry interaction overwhelmingly takes place at formal Center meetings. Therefore, to the extent that communication and interaction are important, the effectiveness of these meeting is critical to Center success.

While it is too early to talk about long-term outcomes of the Centers, including their impact on the careers of participating faculty and students, some of their intermediate results are beginning to become more apparent. Centers do not appear to be having a significant nor widespread impact on how research is conducted within the university or industry although a sizeable number of university scientists (and a small number of

industry scientists) report "some" change has occured in their research topics and issues. Not suprisingly, given the fundamental research focus of the Centers, few companies are reporting a direct impact on their products and processes. Thus, at this juncture Centers appear unlikely to have a radical effect on the research enterprise or the development of new technologies. However, based on the amount of money being spent on Center-stimulated research back in corporate labs (over $5 million for the first 8 Centers), these organizations do appear to be functioning as useful technology transfer vehicles for industrially relevant basic research. As noted above, the long-term impact of this increase in fundamental knowledge to industry remains to be seen.

Although only suggestive, correlative findings provide the basis for some interesting speculation about the processes involved in establishing and maintaining a Center and, for firms, capitalizing on their investment. For instance, although our findings indicate most industrial members were not part of the university's old-boy network, correlative analyses indicate that university alumni were among the few who became substantially involved in Center planning and maintenance activities. Thus, cranking up the old-boy network may not be a sufficient condition for establishing and maintaining a viable center but, to the extent that some involvement by industry is needed, it may be a necessary condition.

The involvement of various corporate groups in Centers also provides some basis for speculation. In general, board members report more than one functional group has contact with the Center. Correlative analyses indicate that three different profiles of Center-corporate interaction tend to occur: Central R&D involvement and an absence of engineering/technical group involvement; a chain of interactions with Divisional R&D involvement, engineering/technical group involvement, and production group involvement tending to occur together; and involvement of top management occuring with corporate planning and marketing involvement. While these profiles are preliminary, they may be instructive for university and corporate strategists who want to manage and optimize the contact points for their interactions.

To some extent, our analyses suggest that a Center's benefits are in the eyes of the beholder. Companies seem to have slightly different agendas in mind when they join a Center (technical, training, general knowledege expansion and redirection of university research). These goals are some of the best predictors of Center outcomes: individuals who endorse technical goals report more product outcomes; those who endorse technical or redirecting university research goals also report funding Center-related research in their labs and realized process outcomes; individuals who endorse training goals report interviewing more students. Based on other analyses not reported in in this document, it appears that these different scenarios are playing out across Centers and not within specific Centers. In the final analysis, the ability of Centers to fulfill different needs (technical, training, human resource) for different firms may be their most important attribute.

More intriguing is the significant relationship between having less seniority in one's firm with reports of new research investments/realized process outcomes and realized product outcomes. Obviously having less seniority is simply a proxy for a constellation of attitudes, expectations and behaviors which set these board members apart from other board members. Although it would be very valuable to know what these individuals are doing differently, particularly back at their home office, the current data set does not allow us to explore these questions.

As the number of Centers increases and the existing Centers mature, data will become available to answer the questions of whether the findings from the present analysis are true within or across Centers, how Centers change over time and the direction of causality for some of the correlations found in these data. These analyses and information from other ongoing components in the Centers evaluation should provide a basis for judging the overall success of the IUCRC Program.

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APPENDIX A

ID CODE #_____

Center for Communications and Signal Processing
North Carolina State University

INDUSTRIAL SPONSOR QUESTIONNAIRE

In order to understand the relationship of the Center with its industrial sponsors, it would be useful to have some background about the people who work with the Center such as yourself. Questions 1 to 9 are designed to give the assessment team some data about you, your experience, and your job within the firm.

1. How many years have you spent with ITT? _____

2. How many years have you spent in research and development with ITT? _____

3. How many years have you spent in industry in general? _____

4. How many years have you spent in research and development in industry? _____

5. To whom do you report in your company? (title or position only)

_____

6. How many organizational levels are there between you and the chief executive officer? _____

7. How many people report directly to you? _____

How many report to you through your subordinates? _____

8. What is the highest degree you have received? _____

   In what field? _____

9. Do you have a degree from or have you taken course work at North Carolina State University?

   ___ Yes

   ___ No

We are also concerned with the decision making and logistics associated with your company's involvement with the Center. We know that in general the scope of discussion in companies about Center participation has varied widely; so has the amount of prior contact with university personnel. Items 10 to 20 are intended to help us understand the early formation of Center programs.

10. Prior to participation of ITT in the Center, was ITT involved in any of the following activities with university personnel now associated with the Center? (Check all that apply)

    ___ Use of faculty as consultants

    ___ Contract research projects

    ___ General support of faculty research

    ___ Support of student thesis research

    ___ Faculty exchange

    ___ Student exchange

    ___ Other (please specify)

    _____

11. Prior to the participation of ITT in the Center, how frequently did you personally have contact with personnel now affiliated with the Center?

___ Several times per week

___ Several times per month

___ Several times per year

___ Rarely or never

12. Were you involved in any of the following activities prior to the establishment of the Center? (check all that apply)

___ Recruitment of new member companies

___ Organizing meetings

___ Proposal writing

___ Planning

___ Building support within the university

___ Other (please specify _____)

13. What is the approximate total cost of your company's participation in the Center in addition to the yearly fee?

| | |
|---|---|
| Travel expenditures | $_____ |
| Staff time | $_____ |
| Space | $_____ |
| Additional direct or indirect contributions (please specify _____) | $_____ |

14. What functional groups in your company work directly with the Center? (check all that apply)

| | Regularly | Occasionally |
|---|---|---|
| Central R&D staff | ___ | ___ |
| Divisional R&D staffs | ___ | ___ |
| Production staff | ___ | ___ |
| Marketing staff | ___ | ___ |
| Engineering/technical staff | ___ | ___ |
| Corporate planning staff | ___ | ___ |
| Other _____ | ___ | ___ |

15. How many organizational levels in your firm had to give explicit approval to your participation in the Center? ____

16. How many individuals at your level in your company had to concur with the decision to participate in the Center? ____

17. To what extent is your top management involved with the activities of the Center?

___ Completely

___ Considerably

___ Some

___ Not at all

18. Approximately how many people in your company have requested information from you concerning specific activities or projects of the Center? ____

19. Approximately what percentage of these information requests can be classified as technical in nature? ____%

Approximately what percentage concern administrative or operational issues of the Center? ____%

20. Do you currently take an active role in any of the following activities of the Center (check all that apply)?

___ Recruitment of new member companies

___ Organizing meetings

___ Proposal writing

___ Planning

___ Building support within the university

___ Other (please specify_____)

A primary concern of this assessment is the various results and benefits that have accrued to companies from participation in the Center. Please be as objective and candid as possible, since in the long run it will be to the Center's advantage to understand its strengths and limitations fully. The remainder of this questionnaire focuses on outcomes, results, and potential benefits.

21. How would you rate the overall research program in the Center compared to similar research programs in other U.S. universities?

___ Top 2%

___ Top 10%

___ Above average

___ Below average

___ Not comparable, because...

_____

22. How satisfied are you with the following features of the Center?

| | Completely | A Great Deal | Some | Not at All |
|---|---|---|---|---|
| Technical quality of the research | ___ | ___ | ___ | ___ |
| Communications between Center staff and your company | ___ | ___ | ___ | ___ |
| Center administrative practices | ___ | ___ | ___ | ___ |
| Responsiveness of the Center to industry needs | ___ | ___ | ___ | ___ |

23. Are there any particular features of the Center operations and results with which you are especially satisfied?

24. Are there any particular features of the Center operations and results with which you are dissatisfied?

25. How <u>important</u> to you are the following goals and outcomes of the Center?

| | Extremely Important | Considerably Important | Somewhat Important | Not at all Important |
|---|---|---|---|---|
| General expansion of knowledge in this technical area | ___ | ___ | ___ | ___ |
| Enhancement of graduate student technical training | ___ | ___ | ___ | ___ |
| Enhancement of graduate students' understanding of industry | ___ | ___ | ___ | ___ |
| Redirection of university research toward industrial problems | ___ | ___ | ___ | ___ |
| Enhancement of quality of industrial research | ___ | ___ | ___ | ___ |
| Development of new research projects in your firm | ___ | ___ | ___ | ___ |
| Development of patentable products in your firm | ___ | ___ | ___ | ___ |
| Development of commercialized products in your firm | ___ | ___ | ___ | ___ |

26. Do you think that the Center has established realistic goals and objectives?

___ Yes

___ No

___ Maybe

27. How likely is it that your company will realize tangible benefits in the following areas as a result of your participation in the Center?

| | Almost Certain | Pretty Likely | Somewhat Likely | Scarcely Likely |
|---|---|---|---|---|
| Better personnel recruitment | ___ | ___ | ___ | ___ |
| Improved research projects in your company | ___ | ___ | ___ | ___ |
| Patentable products | ___ | ___ | ___ | ___ |
| Commercialized products | ___ | ___ | ___ | ___ |

28. Approximately how many new research projects have been stimulated in your research laboratories by the Center activities? _____

How much is this in terms of research dollars? _____

What percentage is this of your total R&D budget? _____

In terms of person-years of full-time-equivalent staff? _____

29. Has participation in the Center activities stimulated other outside research contracts with faculty or another laboratory?

___ Yes

If so, approximately how many research dollars? _____

___ No

___ Don't know

30. To what extent has the research conducted at the Center caused changes in the R&D projects in your company?

| | A Lot | Some | A Little | Hardly Any |
|---|---|---|---|---|
| Research topics and issues | ___ | ___ | ___ | ___ |
| Research methods and procedures used | ___ | ___ | ___ | ___ |
| Criteria and methods used to evaluate research products | ___ | ___ | ___ | ___ |

31. If the the Center program has caused some changes in the R&D projects you conduct, what specifically are these changes?

32. Has your participation in the Center had any effect on the following in your company?

| | Yes | No | Maybe | Not Applicable |
|---|---|---|---|---|
| Improvements in products and services | ___ | ___ | ___ | ___ |
| Changes in warranty and complaints in view of improvements in products | ___ | ___ | ___ | ___ |
| New products developed due to related efforts | ___ | ___ | ___ | ___ |
| Changes in cost of products to users (price changes or decreased product maintenance) | ___ | ___ | ___ | ___ |

| | Yes | No | Maybe | Not Applicable |
|---|---|---|---|---|
| Reduction of production costs | ___ | ___ | ___ | ___ |
| Improvement in processes and methods of production | ___ | ___ | ___ | ___ |
| Increased uniformity of products | ___ | ___ | ___ | ___ |
| Improved product or process design | ___ | ___ | ___ | ___ |
| Improved capability to deal with government regulations | ___ | ___ | ___ | ___ |
| Improved capability to cooperate with outside scientists | ___ | ___ | ___ | ___ |

33. How many students trained in the Center research projects have been interviewed for possible employment in your company? ____

How many have actually been hired? ____

34. How many university scientists from the Center have spent time working on-site in your company's labs? ____

How many scientists from your company have spent time working on-site at the Center? ____

35. To what extent are you generally satisfied with the operations and activities of the Center?

___ Completely

___ Considerably

___ Some

___ Not at all

ID CODE # _____

IUCR Center for Communications and Signal Processing (CCSP)
North Carolina State University

FACULTY QUESTIONNAIRE

In order to understand the relationship of CCSP with its industrial sponsors, it would be useful to have some background about prior relationships with participating companies. Questions 1 and 2 deal with this prior industrial experience of Center personnel.

1. Prior to the establishment of CCSP, how frequently did you have contact with individuals from the following member companies?

| | Several Times per week | Several Times per month | Several Times per year | Rarely or Never |
|---|---|---|---|---|
| Carolina Power & Light | ___ | ___ | ___ | ___ |
| Digital | ___ | ___ | ___ | ___ |
| Exxon | ___ | ___ | ___ | ___ |
| GTE | ___ | ___ | ___ | ___ |
| IBM | ___ | ___ | ___ | ___ |
| ITT | ___ | ___ | ___ | ___ |
| Western Union | ___ | ___ | ___ | ___ |
| Westinghouse | ___ | ___ | ___ | ___ |
| Rockwell | ___ | ___ | ___ | ___ |
| General Electric | ___ | ___ | ___ | ___ |
| Northern Telecom | ___ | ___ | ___ | ___ |

2. Approximately what percentage of your contacts with industry prior to the Center have been of the following types?

| | |
|---|---|
| Individual consulting | ____% |
| Contract research projects | ____% |
| Faculty exchange | ____% |
| Supervision of student exchange | ____% |
| Other (please specify) | |
| _____ | ____% |

Each university/industry cooperative center represents a unique organizational design. In order to understand better the overall Centers program, we would like to know about some of the incentives, structures, and decision processes which operate in CCSP. Questions 3 to 6 deal with these dimensions of structure and processes.

3. Please describe your project(s) and other time commitments involved in CCSP:

| Name and Academic Rank | Tenured? (yes/no) | Projects in which involved | Percentage of time allocated to each project |
|---|---|---|---|
| | | | |

4. For each of the following types of decisions affecting CCSP, please use the scale below to indicate the extent of influence which each group, person, or procedure has over those decisions. Place the appropriate number on the scale below in each blank.

1 = no influence 2 = some influence 3 = a lot of influence

4 = almost complete control

| | University Administration | Center Directors | Faculty | Industry Advisory Board | Students | Established University Procedures |
|---|---|---|---|---|---|---|
| Planning and strategy | ___ | ___ | ___ | ___ | ___ | ___ |
| Project selection | ___ | ___ | ___ | ___ | ___ | ___ |
| Conduct of the research | ___ | ___ | ___ | ___ | ___ | ___ |
| Evaluation of the research | ___ | ___ | ___ | ___ | ___ | ___ |
| Budget and logistics | ___ | ___ | ___ | ___ | ___ | ___ |
| Appointments of faculty and staff | ___ | ___ | ___ | ___ | ___ | ___ |

5. To what extent does faculty participation in CCSP contribute to consideration for tenure, promotion, or salary increases?

___ A great deal

___ A moderate amount

___ A little

___ Not at all

6. Please list the other outside groups, individuals, etc. with which CCSP has significant contact about its operations.

A primary concern of this assessment is the various results and benefits that have accrued to your university and to the companies from participation in CCSP. Please be as objective and candid as possible, since in the long run it will be to the Center's advantage to fully understand its strengths and limitations. The remainder of this questionnaire focuses on outcomes, results, and potential benefits.

7. How satisfied are you with the following features of CCSP?

| | Completely | A Great Deal | Some | Not at all |
|---|---|---|---|---|
| Technical quality of the research | ___ | ___ | ___ | ___ |
| Communications between Center staff and industrial participants | ___ | ___ | ___ | ___ |
| CCSP administrative practices | ___ | ___ | ___ | ___ |
| Responsiveness of CCSP to industry needs | ___ | ___ | ___ | ___ |

8. In your view, how satisfied is industry with the following features of CCSP?

| | Completely | A Great Deal | Some | Not at all |
|---|---|---|---|---|
| Technical quality of the research | ___ | ___ | ___ | ___ |
| Communications between Center staff and industrial participants | ___ | ___ | ___ | ___ |
| CCSP administrative practices | ___ | ___ | ___ | ___ |
| Responsiveness of CCSP to industry needs | ___ | ___ | ___ | ___ |

9. How important to you are the following goals and outcomes of CCSP?

| | Extremely Important | Considerably Important | Somewhat Important | Not at all Important |
|---|---|---|---|---|
| General expansion of knowledge in this technical area | ___ | ___ | ___ | ___ |
| Enhancement of graduate student technical training | ___ | ___ | ___ | ___ |
| Enhancement of graduate students' understanding of industry | ___ | ___ | ___ | ___ |
| Redirection of university research toward industrial problems | ___ | ___ | ___ | ___ |
| Enhancement of quality of industrial research | ___ | ___ | ___ | ___ |
| Development of new company research projects | ___ | ___ | ___ | ___ |
| Development of patentable products | ___ | ___ | ___ | ___ |
| Development of commercialized products | ___ | ___ | ___ | ___ |

10. How likely is it that the university will realize tangible benefits in the following areas as a result of participation in CCSP?

| | Almost Certain | Pretty Likely | Somewhat Likely | Scarcely Likely |
|---|---|---|---|---|
| Improved knowledge base | ___ | ___ | ___ | ___ |
| Better student recruitment | ___ | ___ | ___ | ___ |
| Better student placement | ___ | ___ | ___ | ___ |
| Better faculty recruitment | ___ | ___ | ___ | ___ |
| Improved research projects in the university | ___ | ___ | ___ | ___ |
| Increased funds for research from public sources | ___ | ___ | ___ | ___ |
| Increased funds for research from private sources | ___ | ___ | ___ | ___ |
| Increased university patent activity | ___ | ___ | ___ | ___ |

11. To what extent is the research conducted at CCSP different from the research projects typically conducted by faculty associated with the Center?

| | A Lot | Some | A Little | Hardly Any |
|---|---|---|---|---|
| Research topics and issues | ___ | ___ | ___ | ___ |
| Research methods and procedures used | ___ | ___ | ___ | ___ |
| Criteria and methods used to evaluate research projects | ___ | ___ | ___ | ___ |

Specifically, in what ways has the Center program affected the nature of faculty research?

12. In your opinion, has CCSP had any effect on the following specific outcomes in sponsoring firms?

| | Yes | No | Maybe | Not Applicable |
|---|---|---|---|---|
| Improvements in products and services | ___ | ___ | ___ | ___ |
| Changes in warranty and complaints in view of improvements in products | ___ | ___ | ___ | ___ |
| New products developed to related efforts | ___ | ___ | ___ | ___ |
| Changes in cost of products to users (price changes or decreased product maintenance) | ___ | ___ | ___ | ___ |
| Reduction of production costs | ___ | ___ | ___ | ___ |
| Improvements in processes and methods of production | ___ | ___ | ___ | ___ |
| Increased uniformity of products | ___ | ___ | ___ | ___ |
| Improved product or process design | ___ | ___ | ___ | ___ |
| Improved capability to deal with government regulations | ___ | ___ | ___ | ___ |
| Improved capability to cooperate with outside scientists | ___ | ___ | ___ | ___ |

# APPENDIX C

## VARIABLES USED IN STUDY

I. Respondent Descriptors

A. Industry

1. How many years with company?
2. How many years R&D with company?
3. How many years spent in industry?
4. How many years spent in R&D in industry?
5. How many levels between you and CEO?
6. How many report to you directly?
7. Through others?
8. Highest degree received?

B. Faculty

1. Academic rank?
2. Tenure status?

II. Prior Contact/Center Initiation

A. Industry

1. Degree/coursework at Center University?
2. Prior to Center, was company involved in any of these activities involving University personnel now associated with Center?
   a. Faculty as consultants
   b. Contract research projects
   c. General support of faculty research
   d. Support of student thesis research
   e. Faculty exchange
   f. Student exchange
   g. Other
3. Priorto Center, how frequently did you have personal contact with personnel now in Center?
4. Number of organizational levels that had to give explicit approval to join Center?
5. Number of individuals at same level who had to concur?
6. Involvement in Center planning:
   a. Recruitment of new member companies
   b. Organizing meetings
   c. Proposal writing
   d. Planning
   e. Building support within the university
   f. Other

B. Faculty

1.What percentages of contacts prior to Center were of following types:
   a. Consulting
   b. Contract Research
   c. Faculty Exchange
   d. Student Exchange
   e. Other
2. Frequency of prior contact with each member company

III. Current Operations

A. Industry

1. Do you currently take part in following activities:
   a. Recruitment of new member companies
   b. Organizing meetings
   c. Proposal writing
   d. Planning
   e. Building support within University
   f. Other
2. Approximate total cost of company's participation beyond membership fee?
3. Functional groups that work directly with Center:
   a. Central R&D
   b. Divisional R&D
   c. Marketing
   d. Engineering/technical
   e. Corporate planning
   f. Production
   g. Other
4. To what extent is top management involved in activities of Center?
5. Approximately how many people in your company have requested information from you concerning specific activities of the Center?
   a. Approximately what percentage of these were technical in nature?
   b. Approximately what percentage concerned administrative or operational issues?

B. Faculty

1. Number of projects involved in?
2. Percent time allocated to Center projects?
3. Influence on various Center activities (6 x 6 matrix)?

IV. Goals

A. Industry

1. How important to you are following goals/outcomes:
   a. General expansion of knowledge in technical area
   b. Enhancement of graduates' understanding of industry

(cont.)

Goals (cont.)

c. Enhancement of graduates' technical training
d. Redirection of university's research toward industrial problems
e. Enhancement of quality of industrial research
f. Development of new research projects in firm
g. Development of patentable products in firm
h. Development of commercialized products in firm

2. Do you think Center has established realistic goals?

B. Faculty

1. How important to you are following goals/outcomes:
a. General expansion of knowledge in technical area
b. Enhancement of graduates' understanding of industry
c. Enhancement of graduates' technical training
d. Redirection of university's research toward industrial problems
e. Enhancement of quality of industrial research
f. Development of new research projects in firm
g. Development of patentable products in firm
h. Development of commercialized products in firm

V. Outcomes

A. Industry

1. How satisfied are you with:
a. Technical quality of research
b. Communications center staff/co.
c. Center administrative practices
d. Responsiveness of Center to industry
2. Has Center had effect on following:
a. Improvements in products/services
b. Changes in warranty/complaints
c. New products
d. Changes in cost of products to users
e. Reduction of production costs
f. Improvements in processes/methods of production
g. Increased uniformity
h. Improved product/process design
i. Improved capability to deal with government regulations
j. Improved capability to cooperate with outside scientists
3. How would you rate the overall research program compared to similar programs in U.S. universities?
4. To what extent are you generally satisfied with Center?
5. How likely are following tangible benefits:
a. Better personnel recruitment
b. Improved research projects in company
c. Patentable products
d. Commercialized products

(cont.)

Outcomes (cont.)

6. To what extent has Center research caused changes in company R&D:
   a. Research topics/issues
   b. Methods and procedures
   c. Criteria and methods used to evaluate
7. How many new research projects in company as result of Center
   a. How much in research dollars
   b. As percent of total R&D
   c. In person-years, full-time equivalent
8. Has Center stimulated other outside research contracts
   a. If so, how many dollars
9. How many Center-trained students interviewed
   a. How many hired
10. How many university scientists have worked on-site at company
11. How many company scientists have worked on-site at Center

B. Faculty

1. How satisfied are you with:
   a. Technical quality of research
   b. Communications center staff/co.
   c. Center administrative practices
   d. Responsiveness of Center to industry
2. Has Center had effect on following:
   a. Improvements in products/services
   b. Changes in warranty/complaints
   c. New products
   d. Changes in cost of products to users
   e. Reduction of production costs
   f. Improvements in processes/methods of production
   g. Increased uniformity
   h. Improved product/process design
   i. Improved capability to deal with government regulations
   j. Improved capability to cooperate with outside scientists
3. How likely are the following benefits:
   a. Improved knowledge base
   b. Better student recruitment
   c. Better student placement
   d. Improved University research projects
   e. Increased funding - public
   f. Increased funding - private
   g. Increased patent activity
4. To what extent do Center projects differ from typical research:
   a. Research topics/issues
   b. Methods and procedures
   c. Criteria and methods used to evaluate
5. To what extent does participation in Center influence tenure, promotion, salary?

APPENDIX D
RESULTS OF DATA REDUCTION

I. INDUSTRY RESPONDENTS

| VARIABLES (LOADING) | | FACTOR (EIGENVALUE) |
|---|---|---|
| **Respondent Descriptors** | | |
| How many years with company? | (.6484) | |
| How many years R&D with company? | (.9684) | Seniority (2.6) |
| How many years spent in industry? | (.5189) | |
| How many years in R&D in industry? | (.8899) | |
| How many levels between you and CEO? | | Levels to CEO |
| How many report to you directly? | | Number reporting directly |
| Through others? | | Number reporting through others |
| Highest degree? | | Highest degree held |
| **Prior Contact/Center Initiation** | | |
| Degree/coursework at Center University? | | Degree from Center university |
| Prior to Center, how frequently did you have personal contact with personnel now in Center? | | Frequency of prior contact |
| InvolvementinCenterplanning: (Count number checked.) | | Number of Center planning activities in which individual involved |
| a. Recruitment of new member companies | | |
| b. Organizing meetings | | |
| c. Proposal writing | | |
| d. Planning | | |
| e. Building support within the university | | |
| f. Others | | |
| Number of organizational levels to give explicit approval to join Center? | | Number of organizational levels to approve joining Center |
| Number of individuals at same level who had to concur? | | Number of individuals to concur |

| VARIABLES | | FACTOR |
|---|---|---|
| **Goals** | | |
| How important to you are following goals/outcomes: | | |
| a. General expansion of knowledge in technical area | | General expansion of knowledge |
| b. Enhancement of graduates' understanding of industry | (.9168) | |
| c. Enhancement of graduates' technical training | (.6490) | Training goals (1.34) |
| d. Enhancement of quality of industrial research | (.4551) | |
| e. Development of new research projects in firm | (.6225) | Technical goals |
| f. Development of patentable products in firm | (.7693) | (1.91) |
| g. Development of commercialized products in firm | (.7358) | |
| h. Redirection of university research towardindustrial problems | | Redirection of university research |
| **Current Operations** | | |
| Do you currently take part in following activities: (Count number checked.) | | Involvement of respondent in Center activities/involvement of Divisional R&D (1.08) |
| a. Recruitment of new member companies | | |
| b. Organizing meetings | | |
| c. Proposal writing | (.4686) | |
| d. Planning | | |
| e. Building support within University | | |
| f. Other | | |
| Functional groups that work directly with Center | | |
| a. Divisional R&D | (.6979) | |
| b. Central R&D | | Central R&D |
| c. Marketing | | Marketing involvement |
| d.Engineering/technical | | Engineering/technical involvement |
| e. Corporateplanning | | Corporate planning involvement |
| f. Production | | Production involvement |
| g. Other | | Other group involvemen |

| VARIABLES | | FACTOR |
|---|---|---|
| Current Operations (cont.) | | |
| Approximate total cost of company's participation beyond membership fee? | | Total cost above yearly fees |
| To what extent is top management involved in activities of Center? | | Extent of top management involvement |
| Outcomes | | |
| How satisfied are you with: | | |
| a. Technical quality of research | (.4482) | |
| b. Communications center staff/co. | (.4710) | |
| c. Center administrative practices | (.6118) | |
| d. Responsiveness of Center to industry | (.5623) | Satisfaction/expected benefits (3.51) |
| Do you think Center has established realistic goals | (.4996) | |
| To what extent are you generally satisfied with Center | (.7521) | |
| How likely are following tangible benefits: | | |
| a. Better personnel recruitment | (.5382) | |
| b. Improved research projects in company | (.4517) | |
| To what extent has Center research caused changes in company R&D: | | |
| a. Research topics/issues | (.5454) | |
| To what extent has Center research caused changes in company R&D: | | |
| b. Methods and procedures | (-.6220) | Changes in research methods (1.97) |
| c. Criteria and methods used to evaluate | (-.4528) | |
| How many new research projects in company as result of Center | (.3957) | |
| How much in research dollars | (.8569) | |
| In person-years, full-time equivalent | (.7900) | |
| Has Center had effect on following: | | Realized outcomes/new research (7.05) |
| a. Improvements in products/ services | (.4071) | |
| b. New products | (.5815) | |
| c. Changes in cost of products to users | (.8465) | |
| d. Reduction of production costs | (.6966) | |

(cont.)

| VARIABLES | | FACTOR |
|---|---|---|
| Outcomes (cont.) | | |
| e. Improvements in processes/methods of production | (.7205) | |
| f. Increased uniformity | (.8229) | |
| g. Improved product/process design | (.3744) | |
| How likely are following tangible benefits: | | |
| a. Patentable products | (-.6914) | |
| b. Commercialized products | (-.8074) | Expected direct benefit (1.76) |
| New research projects in company as result of Center as percent of total R&D | (-.4948) | |
| How many university scientists worked on-site at company | (-.5399) | Personnel exchange (1.31) |
| How many company scientists have worked on-site at Center | (-.6906) | |
| Has Center stimulated other outside research contracts? | | Outside research contracts |
| If so, how many dollars? | | Outside research contracts ($) |
| How many Center-trained students interviewed? | | Students hired |
| How many hired? | | Students interviewed |

II. FACULTY RESPONDENTS

| VARIABLES (LOADING) | FACTOR (EIGENVALUE) |
|---|---|
| **Respondent Descriptors** | |
| Academic rank | Academic rank |
| Tenure status | Tenure status |
| **Prior Contact/Center Initiation** | |
| Approximately what percentage of your contacts with industry prior to the Center were of the following types? | |
| a. Prior consulting | Prior consulting |
| b. Prior research | Prior research |
| c. Prior faculty exchange | Prior faculty exchange |
| d. Prior student exchange | Prior student exchange |
| e. Other prior contact | Other prior contact |
| Frequency of prior contact | Frequency of prior contact |
| **Current Operations** | |
| Number of Center projects | Number of Center projects |
| Percent time on Center projects | Percent time on Center projects |
| **Goals** | |
| How important to you are the following goals/outcomes: | |
| a. Enhancement of quality of industrial research (.5256) | |
| b. Development of new research projects in firm (.6967) | Technical goals (2.53) |
| c. Development of patentable products in firm (.7323) | |
| d. Development of commercialized products in firm (.8030) | |
| e. Redirection of university's research towardindustrial problems (.4064) | |
| f. General expansion of knowledge in technical area (.4148) | |
| g. Enhancement of graduates' understanding of industry (.4802) | Training Goals (1.02) |
| h. Enhancement of graduates' technical training (.9506) | |

| VARIABLES | | FACTOR |
|---|---|---|
| **Influence** | | |
| Research-director | (.7641) | |
| Research-board | (.7058) | |
| Evaluation-director | (.6117) | |
| Evaluation-board | (.7230) | |
| Budget-university | (.5343) | |
| Budget-director | (.4435) | |
| Budget-board | (.6540) | |
| Budget-procedures | (.4661) | Director/board influen (8.43) |
| Appointments-university | (.4662) | |
| Appointments-director | (.5518) | |
| Appointments-board | (.5986) | |
| Planning-university | (.5164) | |
| Planning-director | (.4116) | |
| Planning-board | (.7551) | |
| Planning-procedures | (.5049) | |
| Projects-university | (.5058) | |
| Projects-director | (.5994) | |
| Projects-board | (.6619) | |
| Planning-faculty | (.5774) | |
| Projects-faculty | (.7078) | |
| Research-faculty | (.4230) | Faculty influence (3.58) |
| Evaluation-faculty | (.7967) | |
| Evaluation-student | (.6094) | |
| Budget-faculty | (.6058) | |
| Appointments-faculty | (.6230) | |
| Research-university | (.5387) | |
| Research-students | (.3699) | |
| Research-procedures | (.5364) | University administra- tion/procedures influence (2.16) |
| Evaluation-university | (.7467) | |
| Evaluation-procedures | (.7604) | |
| Appointment-procedures | (.4344) | |
| Planning-students | (.3656) | |
| Projects-students | (.6336) | Student influence (1.64) |
| Projects-procedures | (.6648) | |
| Budget-students | (.4235) | |
| Appointments-students | (.6720) | |

| VARIABLES | | FACTOR |
|---|---|---|
| **Outcomes: Industry** | | |
| Has Center had effect on following in sponsoring firms: | | |
| a. Improvements in products/ services | (.6721) | |
| b. New products | (.8567) | |
| c. Changes in cost of products to users | (.8160) | Estimated industry outcomes (5.82) |
| d. Reduction of production costs | (.7909) | |
| e. Changes in warranty | (.8447) | |
| f. Improvements in processes/ methods of production | (.8618) | |
| g. Increased uniformity | (.7858) | |
| h. Improved product/process design | (.7233) | |
| i. Improved capability to deal with government regulations | (.6609) | |
| How satisfied do you think sponsors are with: | | |
| a. Technical quality of research | (.4905) | |
| b. Communications center staff/co. | (.7023) | Estimated industry satisfaction (1.90) |
| c. Center administrative practices | (.6479) | |
| d. Responsiveness of Center to industry | (.8206) | |
| **Outcomes: University** | | |
| How likely is it that the University will realize tangible benefits in the following areas as a result of the Center: | | |
| a. Improved knowledge base | (.3633) | |
| b. Better student recruitment | (.8256) | |
| c. Better student placement | (.6253) | Expected benefits (3.45) |
| d. Better faculty recruitment | (.8325) | |
| e. Improved research projects | (.6757) | |
| f. Increased public funding | (.4728) | |
| g. Increased private funding | (.5426) | |

| VARIABLES | | FACTORS |
|---|---|---|
| Outcomes (cont.) | | |
| To what extent is the research conducted at the Center different from research projects typically conducted by faculty associated with the Center? | | |
| a. Research topics and issues | (.8170) | Difference in research (1.77) |
| b. Research methods and procedures used | (.7738) | |
| c. Criteria and methods used to evaluate research projects | (.6845) | |
| How satisfied are you with: | | |
| a. Technical quality of research | (.7135) | Satisfaction (1.26) |
| b. Communications center staff/co. | (.5176) | |
| c. Center administrative practices | (.4794) | |
| d. Responsiveness of Center to industry | (.5558) | |
| To what extent does participation in the Center contribute to consideration for tenure, promotion or salary increases? | | Influence of Center on career |
| How likely is it that the University will realize tangible benefits in the following areas as a result of the Center? | | University Patent Activity |
| h. Increased university patent activity | | |

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