Industry–University Research Centers: A Multivariate Analysis of Member Retention

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ABSTRACT. Although a growing literature documents the benefits of industry–university research centers, most centers experience a significant amount of turnover among their industrial members. In order to gain a better understanding of this phenomenon, the current study attempts to identify factors that predict member renewal (DV). Questionnaire data were collected from industrial respondents ($N = 249$) participating in 39 centers funded by the NSF IUCRC program. Structural, member benefits and administrative process variables were used to predict the dependent variable. Logistic regression analyses identified three significant predictors: professional networking benefits, research relevance and administrative operations. Implications of these findings for public policy, cooperative research management and future research are discussed.

JEL Classification: L33, 031, 032, 038

1. Introduction

As other papers in this issue point out, interactions between industry and university have become an increasingly important part of the operations of U.S. research universities over the past several decades. One need look no further than the university research budget to support this assertion. According to statistics published by the National Science Board (1996, 1998) industry support of university research has doubled over the past two decades, growing at annual rate of about 8%. In fact, support from industry for academic R&D grew faster than funds from any other source.

In spite of this growth, many observers are clearly under-whelmed when they learn that industry currently supports less than eight percent of university research. However, this statistic ignores the simultaneous effect of our partnership-based public policy. During the same period, government, both national and local, have become major co-funders of cooperative research (Coburn, 1995). In fact, according to research by Cohen and his colleagues (1994), industry–university research centers in the U.S. had research expenditures of $2.53 billion, accounting for roughly 15% of university research funding. Add to this support for traditional cooperative activities like consulting and contract research and industry-sponsored and industry-leveraged government research probably accounts for 20–25% of university R&D.

As the research of Cohen et al. (1994) points out, a great deal of this growth can be attributed to expansion of a single form of partnership: industry–university research centers. According to their estimates, almost seventy percent of industry's support for academic research is channeled through the roughly 1100 industry–university centers they identified in 1993. Consistent with these findings, Feller (1999) has called industry university centers "the dominant form of industry support of academic R&D." (p. 54). While the expansion of these complex boundary-spanning organizations has generally had positive impacts, they also present the U.S. universities that manage them and the social scientists that study cooperative research with a new set of challenges.

Industry–university centers

At one level, a industry–university research center is simply an organized research unit (ORU), that is a semi-autonomous research entity within a university that operates independently of academic departments (Friedman and Friedman, 1986). ORUs typically involve multidisciplinary teams of researchers, a portfolio of research projects (which

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generally are organized into thrusts) and, sometimes, own or have access to some significant piece of equipment and/or facilities.

However, from an organizational standpoint, industry–university research centers are much more than this definition implies. They are complex boundary-spanning structures or organizations (e.g., organizations that facilitate transactions between other organizations) that involve division of labor, leadership, communication systems, monitoring and control systems, etc. (Gray and Walters, 1998). Further, industry–university research centers (or cooperative research centers as they are sometimes called) tend to be more organizationally complex than other organized research units.

> *CRCs* [*cooperative research centers*] *typically address a broad range of research from basic to mission-driven; they serve multiple sponsors from an industry or sector* (*including government and non profit organizations*) *as opposed to a single company or government sponsor; and they serve as a training environment for graduate students and, therefore, must address educational and other goals . . . In short, CRCs tend to be very complex, multi-faceted research enterprises.* (*Gray, in press*)

Research on centers. Fortunately, an extensive research literature has developed on industry–university cooperation in general and industry–university research centers in particular. These activities are reviewed in much greater detail elsewhere (e.g., Coburn, 1995; Lee, 1996; Feller, 1997; Gray, 2000). For our purposes, a brief overview of this literature should be informative.

As we have discussed elsewhere (Gray, in press), this body of research appears to be impressive in some respects and deficient in others. For instance, while the literature on industry–university research centers has included the typical fare of case studies (which basically involve program descriptions) and opinion pieces, it also includes a relatively large number of outcome evaluations. Most of these studies focus on the benefits firms derive from participating in centers, in particular, technology transfer benefits. Studies of the National Science Foundation's Engineering Research Centers (SRI, 1997), Science and Technology Centers (Fitzsimmons *et al*., 1996) and Industry–University Cooperative Research Centers (Scott, 1994) are representative of this work. Other studies have focused on the number and quality of the scholarly outputs from centers (e.g., Fitzsimmons *et al*., 1996) and student outcomes (e.g., Scott, Schaad, and Brock, 1990). The use of sophisticated multi-item questionnaires, statistical sampling procedures and follow up surveys enhances the value of this research.

The findings of these studies have generally demonstrated positive outcomes. For instance, according to Feller (1999): "Both industrial and university participants report a broad set of benefits for these centers, including patents and licenses, but extending well beyond these markers of technology transfer" (p. 54). On the other hand, it is important to note that there are still gaps and shortcomings in this literature. The current study attempts to address two of these: a failure to examine the contribution of organizational factors and a reliance on inferentially weak analytic techniques.

Organizational factors: a missing link. Unfortunately, researchers have paid very little attention to organizational and management aspects of industry–university research centers and how they might affect center outcomes. To a large extent what we know about center management comes from two sources: non-research (and unpublished) site-visit audits of centers by their funding sponsors and descriptive accounts of various management or process factors embedded within outcome studies. More sophisticated predictive analyses are essentially non-existent. This is in stark contrast to the research literature on industrial alliances, a similar but non-university-affiliated organization, which includes some sophisticated multivariate analyses of the relationship between organizational factors and outcomes (e.g., Sakikibara, 1997). This state-of-affairs leaves us with virtually no empirical research on how organizational and management factors affect the outcomes of industry–university centers.

The current study is a modest attempt to begin filling this gap by attempting to understand the factors that contribute to an important organizational outcome—the decision by a firm to renew their participation in a center. Membership termination (or its converse, renewal) is an important issue for at least two reasons: it is a good

proxy for member satisfaction; and because it involves a loss of critical revenues and other inputs (e.g., advice), it constitutes a major stressor for the center. According to data from one center program (Gray and Rudolph, 2000), approximately ten percent of firms drop their membership each year. As a consequence, insights into the factors that contribute to membership renewal would be major boon for center managers.

Since there is no literature on this issue to guide hypotheses, the study focused on addressing the following research goal: To understand the extent to which organizational, research, outcome and administrative factors contribute to member renewal.

2. Methodology

Design

The study involved a cross-sectional multivariate predictive analysis of factors that influence the decision to renew membership in a cooperative research center.

Cooperative research model

Data were collected from participants in the National Science Foundation Industry–University Cooperative Research Center (IUCRC) Program. The NSF IUCRC program has been in existence for over 20 years. One of the program's most important goals is to develop and transfer new knowledge and technology to industry. NSF attempts to achieve this end by providing modest cost-sharing (about $75,000/year) and technical assistance.

A detailed description of the IUCRC model can be found elsewhere (Gray and Walters, 1998). In brief, IUCRCs are university-based, industrial research consortia. The research performed in the centers tends to be strategic or pre-proprietary fundamental research and is carried out primarily by faculty and graduate students. IUCRCs follow a relatively standardized set of policies and procedures, including: members pay an annual fee (usually between $30 and 50 K/year) to support the center's research program; members get equal access to and ownership of all research and intellectual property; findings, know-how and technology are transmitted through a variety of means including periodic reports and semi-annual meetings; and members get one vote on the center's Industrial Advisory Board (IAB). It's worth noting that the IUCRC program was the model upon which a number of federal and state "center of excellence" programs were based. Thus, our findings should be relevant to other center programs.

The IUCRC program currently supports 50 centers that involve over 70 universities, about 700 firms, 500 faculty, 700 graduate students and 200 undergraduate students. Centers tend to be diverse in terms of budget ($400,000–$11,000,000), number of research personnel (5–43), and number of industry members (7–27). Centers also represent diverse areas of technology including: manufacturing, nano/micro technology, chemical processing, biotechnology, advanced electronics, to name only a few.

The IUCRC program has been the focus of a novel on-going evaluation effort that involves the collection of standardized data by on-site evaluators (Gray, 1997). A major focus of this effort has been to collect data that can be used via survey-feedback methodology to help improve center management and performance. Data collected through these efforts has been used to address our research goal.

Instruments

Data were collected via two survey instruments. The "Structure Survey" was completed by center directors and includes 53 questions that examine center-level structural and fiscal information such as funding sources, staff size, and industrial memberships. The "Member Process-Outcome Survey" was completed by center members and contained 30 questions that focus on perceptions and evaluations of the center's research program, its administration, as well as benefits they received. Most questions presented industry members with forced-choice responses about degrees of satisfaction ($1 =$ not satisfied,. . . , $5 =$ very satisfied) or impact (no impact $= 1, \ldots,$ very high impact $= 5$).

Respondents and sample

Industry members in 39 of the 47 centers (83%) returned questionnaires.[1] Of 608 eligible industry members, 330 returned surveys (response

rate = 54%). After eliminating missing data, the final sample consisted of 249 industry members representing 39 centers. Ninety percent of respondents represented primarily large, for-profit firms, and 10% represented government (e.g., defense agency) or not-for-profit organizations. The response sample was not significantly different from the population on any of the structural characteristics examined in the study (see description under "Independent Variables" below).

Measures

In order to simplify the analyses, a rational-empirical scale development strategy was used to reduce the large number of variables contained in the two questionnaires (Jackson, 1970). First, items were grouped into rationally organized variable domains. Next, items in these domains were subjected to factor analysis using varimax (orthogonal) rotation. The goal was to create conceptually meaningful scales that exhibited good psychometric properties (e.g. acceptable reliability coefficients).[2,3] Items that did not appear to belong to a scale were evaluated as individual items. The independent variables were rationally grouped into three domains: structural characteristics, member benefits, and administrative processes. Table I provides descriptive statistics for all variables used in the analysis.

Dependent variable. The dependent variable was a single item that measured intention to renew membership in the center. Industry members were asked, "Will your organization renew its membership?" and presented a 5-point scale ranging from "definitely not" to "definitely yes." Although most respondents indicated they will "probably" (51.2%) or "definitely" (29.0%) renew their membership, 15.5% indicated their renewal is "uncertain", and 2.4% and 2.0% indicated they will "definitely" or "probably" not renew their membership, respectively. Due to the small percentages in these latter categories, respondents indicating they would "definitely" or "probably" not renew were combined with the "uncertain" category. Thus, the dependent variable for analysis consisted of three categories of membership renewal: definitely will renew (29.0%), probably will renew (51.2%), and uncertain/probably-will-not-renew/definitely-will-not-renew (19.8%).

Independent variables. Independent variables were grouped into three variable domains: structural characteristics of the center, member benefits and organizational processes. Although the literature on industry–university cooperation does not provide much guidance on variables that might predict member retention, variables within these domains have proven to be useful predictors of various important R&D-related outcomes (Tornatzky and Fleischer, 1990) and are relevant to the organizational focus of this issue.

The first domain, structural characteristics, consisted of center-level structural and fiscal data about the centers. On average, centers were 9.4 years old and were single-site centers (77%). Staff size, which consisted of all student and faculty scientists combined, averaged 45 researchers ($SD = 28.3$).

Three fiscal variables were examined. Industry members paid their centers an average of $35,736 in dues. When dues were combined, centers had an average membership funding of $485,979. Other funding sources, including university, state, and government sources, accounted for an average of $1.01 million.

The second domain, member benefits, examined technical and collaborative benefits reported by the primary representative of member organizations. Technical benefits (8 items, $\alpha = 0.89$) consisted of R&D and commercialization items. Four R&D items asked about the center's impact (1 = no impact ... 5 = very high impact) on technical capabilities and research projects (e.g., "Stimulated new research projects in my firm"). The commercialization items asked about the center's impact on product development and profitability (e.g., "Improved existing products, processes or services"). Professional Networking (4 items, $\alpha = 0.70$) addressed how participation in the center enhanced student recruitment and improved cooperation with other scientists or members.

The last domain, organizational processes, addressed member perceptions of and satisfaction with the quality of center research and administration. Quality of the Research (4 items, $\alpha = 0.80$) reflected members' satisfaction with the center's research quality (e.g., "innovative"). Research Relevance (4 items, $\alpha = 0.73$) reflected member satisfaction with relevance of the research

Table I
Summary statistics

Variables	Reliability	No. of items	Mean	*SD*
Membership renewal (1 = definitely will, 2 = probably will, 3 = uncertain/probably not/definitely not)	N/A	1	1.91	0.69
Structural characteristics				
Center age (years)	N/A	1	9.36	3.55
Single or multi-site center (single=0, multi=1)	N/A		0.23	N/A
Staff (number of student & faculty scientists)	N/A	1	44.84	28.32
Dues (annual membership fee)	N/A	1	35.74+	9.46+
Membership funding (total center dues)	N/A	1	485.98+	266.34+
Other funding (university, state gov't, etc)	N/A	1	1011.24+	2209.86+
Member benefits				
Technical benefits	0.89	8	2.21	0.80
Professional networking^	0.70	4	0^	0.71
Organizational processes				
Quality of the research	0.80	4	3.89	0.70
Relevance of the research	0.73	4	3.42	0.70
Administrative operations	0.88	8	3.63	0.66

$N = 252$.
+In thousands of dollars.
^Z-score transformations used for items in scale construction.

program (e.g., relevance to short term or long term goals). Finally, Administrative Operations (8 items, $\alpha = 0.88$) addressed member satisfaction with the center's managerial and administrative operations (e.g, "communication between staff and your organization", "planning and development of the research program").

Analyses

The research goal was addressed by attempting to predict retention with the independent variables described above. Logistic regression procedures were used.

3. Results

Table II shows the logistic regression results. The Score Test for the proportional odds assumption yielded a chi-square value of 15.63 ($p < 0.15$, 11df), indicating that the model was appropriate for ordinal logistic regression. The chi-square for the likelihood ratio ($\chi^2 = 100.4$, $p < 0.0001$.) indicated that the model was significant. The Pseudo R^2, a measure of error reduction in prediction, revealed that the model resulted in a reduction of error in prediction of 25%.

An examination of Table II reveals that none of the structural variables, one of the member benefits and two of the organizational processes were statistically significant predictors of retention. In the benefits domain, professional networking, a scale comprised of items that reflect student recruitment benefits and enhanced co-operation with outside scientists and other center members, had a significant impact on retention. The odds-ratio suggest a unit increase in professional networking benefits increases the odds of membership renewal 2.127 times. Technical benefits did not predict renewal.

In the organizational processes domain, relevance of the research, a scale that measured satisfaction with the relevance of the research, and administrative quality, a scale that measured satisfaction with the way the center was administered, had a significant impact on retention. The odds ratios indicate that a unit increase in relevance of the research increases the odds of member-

Table II
Ordinal logit model regressing membership renewal on structural characteristics, member benefits, and organizational processes

Explanatory variables	Log-Odds	Odds-Ratio
A. Structural Characteristics		
Center age (years)	0.059	1.061
Single or multi-site center (single= 0, multi= 1)	−0.483	0.617
Staff (number of student & faculty scientists)	−0.002	0.995
Dues (annual membership fee)	−0.005	0.995
Membership funding (total center dues)	0.000	0.999
Other funding (university, state gov't, etc)	0.000	1.000
B. Member benefits		
Technical benefits	−0.079	0.923
Professional networking	0.755*	2.127*
C. Organizational processes		
Quality of the research	−0.013	0.987
Relevance of the research	0.738*	2.091*
Administrative operations	1.187*	3.276*
Intercept 1	−7.748*	
Intercept 2	−4.662*	
Sample size	249	
Score test for proportional odds assumption	16.02	
−2 LOG L	409.75	
Model chi-square	100.46	
Degrees of freedom	11	
Pseudo R^2	0.25	

Note: Membership renewal, the dependent variable, had three categories: 1 = Definitely will renew, 2 =Probably will renew, 3 = Uncertain/Probably won't renew/Definitely won't renew.
*$p < 0.01$.

ship renewal 2.091 times and a unit increase in administrative operations increases odds of retention 3.276 times. The quality of the research did not predict retention.

4. Discussion

The mix of research support at U.S. universities has changed significantly over the past two decades. While industry's support has doubled during this time, the growth of government-sponsored, partnership-based support has been more dramatic. According to Cohen *et al.* (1994), one-fourth of university support may be derived from a combination of industry and industry-leveraged federal and state dollars.

The growth of multidisciplinary industry–university research centers has been a major contributor to this phenomenon. While research suggests that these organizationally complex boundary-spanning structures have been relatively effective in meeting the needs of both sectors, this same literature has been virtually silent on which factors and processes contribute to various outcomes. This study attempts to shed some light on these issues by examining the extent to which center-level and member-level variables can be used to predict an organizationally important outcome - the intention to renew membership among industry–university research center members.

Our results indicate that a number of organizationally-mediated factors do influence member retention. Specifically, professional networking benefits, satisfaction with research relevance and satisfaction with administrative operations significantly predict the odds that an organization will renew their membership in an IUCRC.

Not surprisingly, organizations that receive benefits are more likely to renew their membership. However, professional networking benefits, not technical benefits, appears to be what drives the renewal decision. While this finding may be surprising to some, it is consistent with related research on similar types of research organizations. For instance, research by Gray *et*

al. (1986) and SRI (1997) suggest that members expected and subsequently report receiving valuable but relatively indirect benefits like new research ideas and top-notch students from their participation in industry–university research centers. Research on a similar type of industrial research organization, multi-member industrial consortia, by Sakikibara (1997) points to similar results. It is probably worth pointing out that these findings may be limited to one organizational form of industry–university partnership—the research center. A comparison of center and project-based partnerships (Gray *et al.*, 1987) found that firms put a much higher premium on direct technical benefits in one-on-one partnerships with the university than in centers.

While renewal does not appear to be contingent on receiving direct technical benefits, it would be a mistake to conclude that the technical dimension of the partnership does not matter. However, when members are considering renewing their membership agreement, relevance not general quality, appears to be paramount. This may also suggest the relative importance of future rather than past payoffs when considering renewal.

Finally, members also appear to recognize the importance of administrative operations to the investment they are making in a center. In fact, our results suggest that administrative operations, a measure which reflects member satisfaction with communications, research planning and management, funding raising, intellectual property management, etc., is the most important predictor of renewal.

Interestingly, there is no evidence that the relatively stable structural characteristics of the centers studied affect member renewal decisions. More established centers, centers that involve multiple research sites, or sites that have more staff, larger budgets and/or lower dues do not appear to have any inherent advantage when members consider renewal.

Implications

These findings appear to have implications for public policy, cooperative research management and future research in this area.

Since the time the IUCRC program was developed back in the early 1970s, both state and federal policy have tended to emphasize the development of very large and highly funded industry–university research centers. While there are undoubtedly good reasons for creating such centers (e.g., big science problems demand big centers) the needs of industry, as reflected in renewal intentions, do not appear to be one of them. IUCRCs vary considerably in terms of staff size (5–43), students (8–60), members (7–27), and budget ($400,000–$11,000,000). However, these proxies for size and resources do not appear to affect the renewal likelihood. Perhaps this should serve as a reminder to the S&T policy community that, if pleasing industry is the standard (a technology-pull perspective), large is not necessarily better.

The implications of our study for managers of centers is more complex but hopefully also more informative. According to our data, center managers who want to retain their members should focus their attention on three issues: insuring that members receive professional networking benefits like recruiting and access to new ideas; delivering a research program that is relevant to their member's needs; and making sure that the administrative operations run efficiently and effectively. In our minds, the centrality of administrative/organizational factors to these factors cannot be overstated. Professional networking benefits and research relevance do not just happen in large, team-based, multidisciplinary centers, they are byproducts of a well orchestrated administrative function.

To date, most organizationally focused research on industry–university cooperation has been primarily qualitative. Although our findings are clearly preliminary and there are many questions left unanswered, we are encouraged by the level prediction achieved by our model. As a consequence, we hope our results demonstrate to the S&T research community not only the feasibility but also the desirability of using quantitative and multivariate approaches when trying to unravel the complicated dynamics involved in industry/university interactions.

Notes

1. Data were collected during 1996 and asked about the previous fiscal year.

2. In order to create scales with similar distributions, mean scores (total/number of items) were calculated.
3. In order to minimize missing data, scales were created if at least 75% of items comprising a scale were complete.

References

Cohen, W.M., R. Florida, and W.R. Goe, 1994, *University–Industry Research Centers in the United States*, Pittsburgh: Carnegie Mellon University.

Coburn, C., 1995, *Partnerships: A Compendium of State and Federal Cooperative Technology Programs*, Columbus: Battelle.

Feller, I. 1999, 'Technology Transfer from universities', in J.C. Smart (ed.), *Higher Education: Handbook of Theory and Research*, Agathon Press, pp. 1–43.

Fitzsimmons. S.J., O. Grad, and B. Lal, 1996, *An Evaluation of the NSF Science and Technology Centers (STC) Program*, Washington, DC: National Science Foundation.

Friedman, R.S. and R.C. Friedman, 1986, *Sponsorship, Organization and Program Change at 100 Universities*, University Park: Pennsylvania State University Institute for Policy Research and Evaluation.

Gray, D.O., W. Hetzner, J.D. Eveland, and T. Gidley, 1986, 'NSF's Industry–University Cooperative Research Centers and the Innovation Process: Evaluation-based Lessons', in D.O. Gray and T. Solomon (eds.), *Technological Innovation: Strategies for a New Partnership*, Amsterdam: North-Holland.

Gray, D.O., E. Johnson, and T. Gidley, 1987, 'Industry–University Projects and Centers: An Empirical Comparison of Two Federally Funded Models of Cooperative Science', *Evaluation Review* **10**, 776–793.

Gray, D.O., 1997, 'Establishing System-Wide Evaluations: Program-Centered Evaluation and the National Science Foundation's Industry–University Cooperative Research Centers', in P.Y. Shapira (ed.), *Manufacturing Modernization: Learning From Evaluation Practices and Results*, Atlanta: Georgia Tech University, pp. 241–250.

Gray, D.O. and J.M. Rudolph, 2000, *National Science Foundation Industry–University Cooperative Research Center Program: Structural Information*, Raleigh: North Carolina State University.

Gray, D.O. and S.G. Walters, 1998, *Managing The Industry–University Cooperative Research Center: A Guide For Directors And Other Stakeholders*, Columbus: Battelle Press, pp. 59–86.

Gray, D.O., 2000, 'Government-Sponsored Industry–University Cooperative Research: An Analysis of Cooperative Research Center Evaluation Approaches', *Research Evaluation*, **8**, 57–67.

Jackson, D.M., 1970, 'A Sequential System For Personality Scales Development', in C. Spielberger (ed.), *Current Topics In Clinical And Community Psychology*, New York: Academic Press, pp. 61–96.

Lee, Y.S., 1996. 'Technology Transfer and the research University: A search for Boundaries of University–Industry Collaboration', *Research Policy* **25**, 843–863.

National Science Board, 1996, *Science and Engineering Indicators 1996*, Arlington: National Science Foundation.

National Science Board, 1998, *Science and Engineering Indicators 1998*, Arlington: National Science Foundation.

Sakikibara, M., 1997, 'Evaluating Government-Sponsored R&D consortia in Japan: Who Benefits and How?', *Research Policy* **26**, 447–473.

Scott, C., 1994, *Understanding Technology Transfer in NSF Industry/University Cooperative Research Centers: Interview Data and Aggregated Descriptive Statistics*, Washington, DC: National Science Foundation.

Scott, C., D. Schaad, and D. Brock, 1990, *A Nationwide Follow-Up Study of graduates of NSF Industry/University Cooperative Research Centers*, Washington, DC: National Science Foundation.

SRI, 1997, *The Impact on Industry of Interaction with Engineering Research Centers*, Washington, DC: National Science Foundation.

Tornatzky, L.G. and M. Fleischer, 1990, *The Processes of Technological Innovation*, Lexington: Lexington Books.