Faculty Outcomes From Industry-University Collaboration: A Multivariate Predictive Study

Beth Marie Meagher, M.S.
Doctoral Graduate Student

Denis O. Gray, Ph.D.
Professor

North Carolina State University
Department of Psychology, Box 7801
Raleigh, NC 27695-7801
USA

bmmeaghe@unity.ncsu.edu
denis_gray@ncsu.edu

LITERATURE REVIEW

The United States spends an enormous amount of money on research and development (R&D) activities. A great deal of this research takes place in institutions of higher education. In 1998, universities conducted approximately 48% of all basic research in the US. In terms of dollars spent, approximately $26.3 billion dollars was provided by the federal government, the university, state and local government, industry, and other sources towards research at universities and other academic institutions. Of this total amount, industry provided $1.9 million dollars, towards university research and development. This amounts to 7% of the total funding for university research. While this amount seems small in comparison to money spent by other sources, the amount of industry funding is growing at the fastest rate among all sources of fund to academic institutions. In 1973, $84 million was spent by industry on university research. In 1997, industry spent $1.7 billion dollars (National Science Foundation, 2000).

One type of linkage that industry can make with the university is the industry-university research center. This novel organization serves an important boundary spanning function for the university. It is described as a semi-autonomous, adaptive organization that exists at the university for the purposes of research and product/process development (Koester & Gray, 1990). Industry-university research centers (IURCs) address a wide range of research issues for a number of industry and government sponsors. The basic structure of the IURC is an administrative core at the university that supports and coordinates interrelated research projects involving faculty, students, and staff from multiple disciplines (Gray, Johnson, & Gidley, 1987). Industry funding is provided by industry "sponsors" who pay an annual membership fee. Some IURCs are also funded by a small government grant however, the majority of funding is still provided by industrial memberships. IURCs are diverse in the type of research they do, their size, and mission. The specific characteristics of the center depend on the scientific discipline

and industries the center is affiliated with (Cohen, Florida, and Goe, 1994). In 1991, there were approximately 1,056 IURCs in the US involving 12,000 faculty, 22,300 doctoral-level research scientists, and 16,800 graduate students. These IURCs had research expenditures of $2.53 billion. Feller (1999) describes the IURC as "the dominant form of industry support for academic R&D" (p. 54).

IURCs have been evaluated using a number of different methods. The results of these evaluations show a number of benefits for industry involved in IURCs. An analysis of IURCs in general showed that one major outcome of the interaction between the two partners was the introduction of new products and processes and the improvement of products and processes that already exist (Cohen, Florida, & Goe, 1994). Lee (2000) listed a number of industry benefits from collaboration with the university; the opportunity to gain access to new research, the development of new products and processes, maintaining a relationship with the university, developing new patents, and solving technical problems. While university research may not lead directly to a new product, it provides information on the essential processes that will make the innovation possible (Mansfield, 1995). In an extensive review of over 120 articles on technology transfer from universities, Feller (1999) states that some of the major reasons for the involvement of firms in IURCs is access to state of the art information, maintaining of relationships with faculty, and access to students.

In spite of the large amount of research that has been done on industry-university research collaboration, there is one population in the relationship that has been relatively neglected in research; the university faculty member. Gray (2000) mentions that this oversight is significant given that the possible negative consequences for faculty involved in this type of collaborative research are frequently mentioned. Faculty are an important part of the research

relationship with industry and knowing more about their participation would help to make the collaboration effort more effective. A search of the literature search on faculty and industry-university collaboration produced 11 studies published in the last 20 years. This literature shows that in general, academic faculty are supportive of industry-university collaboration in research. This support has also shown an increase in the past decade particularly from the engineering and applied science fields. There is also an overall increase in acceptance of applied research by faculty in the past decade (Lee, 1996). A large percentage of engineering faculty would like to see more industry involvement in academic research (Strickland, Kannankutty, & Morgan, 1996). Academic faculty are also open-minded towards changes in the university norms that would facilitate an increase in the amount of collaboration with industry (Campbell, 1997; Campbell & Slaughter, 1999).

Rahm (1994) showed that the type of university in which a faculty member works is important. Faculty involved in industry-university collaboration tend to come from universities that are "firm friendly", that is, the university offers classes and workshops for firm employees, internship opportunities with firms are arranged for students, and the university is involved with companies in activities such as research consortiums. The type of research program of the faculty member is also key, faculty who are involved with industry tend to describe their research programs as multidisciplinary.

Lee (2000) studied motivators for faculty to become involved in industry-university research and their perceived benefits. The four motivators that faculty listed as important reasons for collaborating with industry were to secure funds for research assistant and lab equipment, gain insights into one's own research, test application of theory, and supplement

funds for research. There was a strong correlation between the motivation to participate in research with industry and the benefit received.

While the studies in the current literature present some information about faculty and industry-university research collaboration, there are a few limitations. The main limitation is that the data presented in these studies is primarily descriptive. Only three of the studies provide regression analyses (Lee, 1996; Blumenthal, Campbell, Anderson, Causino, & Louis, 1997; Landry, Traore, & Godin,1996). Another limitation is in the area of methodology. Many of the studies used unrepresentative techniques for obtaining participants, making their results hard to generalize past that sample. Response rate was also a problem for a few of the studies. Few of the studies focused on a particular type of collaboration, instead faculty participating in any type of collaboration with industry were considered for analysis. There is clearly much more to be studied in this area.

The purpose of this study is to examine the satisfaction of faculty who are involved in IUCRs. Currently there appears to be no studies of this type for this organization. The main research question is: What predicts the satisfaction of faculty involved in industry-university research centers? This question will be answered through the analysis of data from an evaluation of industry-university research centers located in major universities throughout the US.

METHOD

Procedure

Data was collected from both Industry University Cooperative Research Centers (IUCRC) and research centers located at a large Research I university in the Southeast. IUCRC faculty data were collected by each of the national evaluators for his or her center(s) and then submitted to the National Evaluation Team to create national baseline data. The

process/outcome survey that was used is part of an annual evaluation of the centers designed to provide feedback for both the center management and center industry members.

In order to diversify the sample of centers used in this study, additional data were collected from other industry-university research consortia located at large Research I university in the Southeast. Seven centers were contacted to participate, four accepted. Data was received from three of the centers.

Setting and Population

In the 2000-2001 evaluation year, there were a total of 50 centers in the IUCRC program. A total of 515 faculty were involved in these centers. Data were collected from 29 of the 50 centers in the program (a 58% center response rate). From the sample of 29 centers that collected data, a total of 207 out of 379 faculty surveys were received (a 54.62% response rate of surveyed universities). For the centers that did not collect faculty data in the 2000-2001 evaluation year, an attempt was made to use data from the previous (1999-2000) evaluation year. This added data from an additional 9 centers (increasing the center response rate to 76%) and increased the number of faculty that received the survey to 519. A total of 46 faculty surveys were returned from these centers (a response rate of 32.86% and a decrease in the overall response rate to 48.75%). The total number of IUCRC faculty respondents was 253. From the non-IUCRC centers, data was received from a total of 22 faculty (a 40% response rate). This brought the total sample size to 275 faculty (an overall response rate of 47.91%).

Measures

Characteristics of the University.

Type of university. Public or private institution.

Research Intensiveness. Research I institutions and non-research I institutions.

Size of the university. Total research budget of the university, measured in thousands of dollars.

Percent of the university budget that the university receives from industry.

Characteristics of the Center.

Size of the center. The number of industry members.

Total operating budget of the center.

Age of center. Number of years that the center had been in existence.

Discipline of the center. Engineering versus another area of science.

Center funding per faculty member.

Faculty Characteristics.

Academic Rank. Assistant professor, associate professor, full professor, or other rank.

Tenure. Tenure, tenure-track, or neither.

Faculty Tangible Benefits. Amount of time, measured in months, the faculty member feels it should take a new center research project to yield tangible results.

Difference in Subjective Estimates of Time till Tangible Benefit: I-U Difference Scores. Difference in months between industry and faculty for a given center for the amount of time a new research project should yield tangible results.

Faculty Report of Research. Self-report comparison of the research performed by the respondent in the center with research conducted outside of the center on three dimensions: basic/applied, broad/narrow scope, longer/shorter time frame.

Technical Benefits (Scale) Benefits the faculty member believes industry has received in R&D efforts and the commercialization of products, processes, and services.(Alpha= .83).

Faculty Benefits

Faculty Academic Freedom. Impact of center involvement on the amount of autonomy in conducting research and the ability to publish research in a timely fashion. (Alpha = .82).

Faculty Benefits. These benefits include: the ability to support graduate students, opportunities for consulting, opportunities for research contracts, access to equipment, chances for promotion and tenure, and amount of interaction with other faculty. (Alpha = .71).

Faculty Symmetry with Industry. Impact the center has had on the faculty member's trust and confidence in industry and their evaluation of the quality of industrial research. (Alpha = .71).

Dependent Variable

Satisfaction (Scale). Satisfaction is measured with three variables: satisfaction with the quality of the research program, satisfaction with relevance to industry needs, and satisfaction with center administration and operations. (Alpha = .80).

Data Analysis

Data analysis consisted of a univariate analysis, bivariate regression, and multiple regression. A "trimming approach" was used in the regression analysis. First, items were examined at the bivariate level. Significant items from the bivariate models were then examined at the multivariate domain level. Finally, significant items from the domain level were examined at the overall multivariate level. A significance value of .05 was used for all analyses.

RESULTS

Bivariate Regression

A total of twenty independent variables were tested, of these thirteen were significant; center size, center age, engineering/non-engineering discipline, center funding per faculty member, public/private university, research I/non-research I university, university research

budget, faculty evaluation of industry, faculty benefits, faculty academic freedom, broad/narrow scope of research, longer/shorter time frame of research, and industry technical benefits.

Multivariate Regression

The first round of multivariate analyses for faculty satisfaction examined the predictor variables by the variable domains: center characteristics, university characteristics, benefits, research characteristics, and industry technical benefits. The results for each model are presented in Table 1.

For center characteristics, three variables were present in the model: center size, center age, center discipline, and the amount of center funding per faculty member. The model explained 7.5% of the variance in faculty satisfaction. Center funding per faculty member and center discipline were both significant ($p<.10$) and had a positive effect. Looking at the standardized coefficients, center discipline had the larger effect on satisfaction. For university characteristics, three variables were in the model; whether the university the faculty member was from was public or private, whether or not the university was a Research I university, and the university research budget. The public/private measure and the university research budget significantly contributed to the model, explaining 9% of the variance. The benefits model included three variables: faculty evaluation of industry, faculty benefits, and faculty academic freedom. Faculty evaluation of industry and Faculty benefits contributed significantly to the model explaining 24% of the variance in the satisfaction measure. The effect size of both independent variables were similar, with faculty evaluation of industry being slightly larger than faculty benefits. The research characteristics model included two variables; whether center research was more broad or narrow than research outside of the center and whether center research has a longer or shorter time frame than non-center research. Only the broad/narrow

measure significantly contributed to the model, explaining 4% of the variance. The final predictor model was industry technical benefits. This model included only one variable, technical benefits; which significantly predicted 6% of the variance in satisfaction.

The overall multivariate model included eight independent variables; center size, center discipline, public/private university, university research budget, faculty evaluation of industry, faculty benefits, broad/narrow scope, and technical benefits. The results for this model are presented in Table 2. Four of the eight variables significantly contributed to the model; center discipline, university research budget, faculty evaluation of industry, and faculty benefits. The model explained 35% of the variance in the satisfaction measure. Each variable had a positive effect on satisfaction, faculty evaluation of industry having the strongest effect, followed by faculty benefits, then center discipline and finally university research budget.

An additional multivariate linear regression analysis was conducted to determine if any of the individual benefits items significantly contributed to faculty satisfaction. The regression model contained the significant variables from the domain level regressions (center discipline, center funding per faculty member, public/private university, university research budget, broad/narrow scope of research, and industry technical benefits). Benefit items were entered into the model in a stepwise format. The results for this analysis are presented in Table 3. The final model contained the significant variables from the domain groups plus the following benefits items: trust and confidence in industry, amount if interaction with other faculty and access to equipment. All of these benefits variables significantly contributed to the model, in addition to center discipline, university research budget and industry technical benefits. All effects were positive, trust and confidence in industrial had the largest effect, followed by the amount of

interaction with other faculty. A total of 37% of the variance was explained in faculty satisfaction by the final model.

DISCUSSION

Many types of linkages are made between the university and industry. One of these is the industry-university research center, which is an organization that serves a boundary spanning function between the university, government, and industry. This growing type of linkage has shown a number of benefits such as the introduction of new products and processes and the improvement of existing products and processes (Cohen, Florida, & Goe, 1994). Although there has been a large amount of research done on industry-university research collaboration and I-U centers, most of this research has focused on the industry side of the relationship. University faculty have been relatively neglected in research. A literature review conducted for this study found only eleven studies on faculty and I-U relationships published since 1986. Though the studies do present information on a number of variables important to I-U collaboration such as characteristics of the faculty member's research program and attitudes of the faculty member towards I-U collaboration, there are limitations to this research. The main limitation is that the data is primarily descriptive. Other limitations are in the area of methodology. There is a clear need for an increase in the amount of research in this area.

The present study sought to address issues concerning the relationship between various variables and faculty satisfaction in the context of industry-university cooperative research centers. The results of the study showed that different organizational levels do make a difference in the prediction of satisfaction. Variables at the institutional, the center, and the individual level predicted satisfaction for faculty members.

At the university level, faculty were more satisfied when they came from universities with larger research budgets. The positive effect of the university research budget on satisfaction is not a surprising result. Larger research budgets mean more money that is available to individual faculty members, making it easier to fund their research programs without having to endure the stress of seeking external funding sources. More money from the university also means less grant money that needs to be spent on things such as equipment or overhead and more money that can be spent on the actual research. This is good for the IUCRC faculty from universities with larger research budgets, as many of the IUCRC centers receive very little funding. Therefore, faculty involved in the centers are working on a tighter budget. Faculty from universities with a larger research funding base are probably better able to cope with the marginal support than faculty at universities with a smaller funding base. It is surprising however, that center funding per faculty member did not predict satisfaction as this measure is closer to the faculty member level.

At the level of the center, faculty were more satisfied when they came from a center with a non-engineering discipline. Upon examination of the disciplines of these centers, it was shown that they represented multidisciplinary fields such textiles, health science and management, and computer software. In comparison to the applied nature of the field of engineering, these fields are of the opposite extreme than was expected, they are even more applied than engineering. Because of the extreme applied nature of these fields, an even tighter coupling with industry is required than is needed in engineering. Therefore, faculty from these centers may express a higher level of satisfaction with being involved in these centers because it brings them in close contact with industry.

At the level of the faculty member, there was more satisfaction among faculty who reported that participation in the center had a positive impact on their receipt of benefits and on the level of symmetry they felt with industry. As explained above, the positive effect of the symmetry with industry variable further reflects the concept that faculty who feel that industry is their peer in research are likely to be more satisfied with the center. This would be a critical variable for a center to be aware of as centers with a mismatch between faculty and industry members might be less successful in their research program than those centers with a closer match.

Finally, an additional regression analysis showed that among the faculty benefits, the most important items are increased interactions with other faculty and access to equipment. This is important, as these are benefits that do not lead to personal gain for the faculty member. Rather, these benefits promote both collaboration and the research program of the individual faculty member. The results of the present study are in agreement with the work of Lee (2000), who suggests that faculty become involved in industry-university research to advance their own research program. This also complements the results of Gray, Johnson, and Gidley (1986) who state that faculty and industry participants from center programs have a primary goal of a general expansion of knowledge rather than patentable products.

Though this research does shed some light in the area of the satisfaction for faculty involved in this type of organization, it is clear that more research is needed to more fully understand the dynamics of this relationship and faculty involvement in industry-university collaboration in general. Further studies could provide a more in depth look at satisfaction for faculty and provide a greater understanding of the processes at work in this type of organization.

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Table 1

Summary of Multiple Regressions of Faculty Satisfaction on the Predictor Variables by Variable Domain

Variable	B	*B*	P
Center Characteristics (n= 249, df=4)			
Center Size	.00	.05	.48
Center age	.02	.11	.11
Center discipline	.42	.22	.00
Center funding per faculty member	.00	.14	.06
R^2	.075		
University Characteristics (n= 246, df= 3)			
Public/Private	-.40	-.17	.01
Research I	.08	.04	.58
University Research Budget	.00	.22	.01
R^2	.09		
Benefits (n= 242, df= 3)			
Faculty symmetry with industry	.39	.35	.00
Faculty Benefits	.37	.22	.00
Faculty Academic Freedom	-.00	-.01	.94
R^2	.24		
Faculty Report of Research (n= 247, df= 2)			
Broad/Narrow	-.16	-.18	.01
Longer/Shorter Time Frame	-.04	-.05	.51
R^2	.040		
Industry Technical Benefits (n= 245, df= 1)			
Industry Technical Benefits	.20	.25	.00
R^2	.06		

Table 2

Summary of Overall Multiple Regression of Faculty Satisfaction on the Predictor Variables

Variable	B	*B*	P
Center Characteristics			
Center Discipline	.30	.16	.02
Center funding per faculty member	.00	.09	.16
University Characteristics			
Public/Private University	-.12	-.05	.45
University Research Budget	.00	.12	.06
Benefits			
Faculty Symmetry with Industry	.37	.34	.00
Faculty Benefits	.38	.23	.00
Faculty Report of Research			
Research is broad/narrow in scope	-.05	-.03	.60
Industry Technical Benefits			
Technical Benefits	.04	.05	.40
R^2	.35		

Note: n= 210, df= 8

Table 3

Summary of Additional Multiple Regression of Faculty Satisfaction on the Predictor Variables and Individual Benefits Variables

Variable	B	*B*	p
Step 1 (n= 209, df=6)			
Center Characteristics			
Center Discipline	.28	.15	.02
Center funding per faculty member	.00	.09	.16
University Characteristics			
Public/Private University	-.15	-.06	.32
University Research Budget	.00	.13	.05
Faculty Report of Research			
Research is broad/narrow in scope	-.01	-.02	.82
Industry Technical Benefits			
Industry Technical Benefits	.08	.10	.10
R^2	.16		
Step 2 (n=209, df=7)			
Benefits Variables			
Amount of interaction with other faculty	.25	.22	.00
R^2 (ΔR^2)	.29(.13)		
Step 3 (n=209, df=8)			
Access to equipment	.15	.15	.02
R^2 (ΔR^2)	.36(.07)		
Step 4 (n=209, df=9)			
Trust and Confidence in industry	.31	.31	.00
R^2 (ΔR^2)	.37(.01)		