# Predictors of Cooperative Research Center Post-Graduation Survival and Success

Presented as part of a Thematic Workshop:
Understanding Cooperative Research Centers: Learning from Success and Failure

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## Abstract

Like other cooperative research centers around the world, Industry/University Cooperative Research Centers (I/UCRCs) are supported by funding from government, but are expected to achieve self-sufficiency after a fixed term. However, there is little research-based evidence about the extent to which government funded center programs, and especially triple helix based programs, are able to make this transition. This study attempts to identify the factors that predict center survival and success after they have graduated from National Science Foundation (NSF) funding. Program sustainability refers to the degree to which a program is able to sustain itself once the initial grant funding comes to an end. It is defined as the continuation of program benefits, activities, and infrastructure (Shediac-Rizkallah & Bone, 1998). Program sustainability is predicted by environmental, organizational, program, and individual level factors. Results showed that 80% of I/UCRCs that received the full 10 years of I/UCRC grant support are still operating in some form today. Likewise, sustained graduated centers are highly successful, maintaining the size and scope of their programs. Presentation will highlight environmental, organizational, and program level variables also identified as predictors that differentiate successful from unsuccessful graduated I/UCRCs. Implications of these findings for program management and public policy will be discussed.

Keywords: program sustainability, centers, program evaluation
Acknowledgement: The authors acknowledge support provided by the National Science Foundation Industry/University Cooperative Research Centers Program (EEC-0631414) in preparing this paper.

## INTRODUCTION

Triple Helix-based programs are often funded by government grants that support their initial development, getting important programs up and running. These programs are often demonstration projects with time-limited funding. However, many times, they are expected to become self-sufficient once their grants end. While such programs are often successful at developing new programs and centers, little is known about how these programs are able to become self-sustaining once initial grant monies are exhausted. This paper focuses on the efforts of NSF funded Industry/University Cooperative Research Centers (I/UCRC) to become self-sustaining, supported by industrial members and other stakeholders.

Over the last three decades, national policy has facilitated greater collaboration in research between industry and academia (National Science Board, 2006; Feller, 1997). These legislative changes have contributed to an increase in collaborative research by reducing barriers and encouraging cross-sector collaboration (Cohen, Florida, & Goe, 1994). This policy landscape is complemented by grant programs and other types of funding for R&D that is conducted jointly between universities and industry.

One example of industry-university linkage mechanisms are cooperative research centers (CRCs). CRCs partner industry and academia, and in some cases government for a collaborative approach to research. These CRCs are cross-sectorial and multidisciplinary, organized by research interest (Gray, 2000). They are intended to bring the producers and users of technology, knowledge, and research together in order to speed the innovation process. In bridging the gap between industry and academia, CRCs produce research that is scientifically important and industrially relevant (Gray & Walters, 1998).

The National Science Foundation's Industry/University Cooperative Research Centers (I/UCRC) Program is one example of a CRC approach to fostering collaboration in research. One of the primary goals of this program, as with many CRC programs, is to create long term partnerships between industry and university. In fact, the NSF explicitly states that its "investment in the I/UCRCs is intended to seed partnered approaches to new or emerging research areas, not to sustain the Centers indefinitely. The Foundation intends for I/UCRCs to gradually become fully supported by… other non-NSF sponsors" (National Science Foundation, 2006). There is significant data about how these centers function while they are funded by NSF. However, there is no empirical information about what happens to I/UCRCs after their grants end. The purpose of this paper is to begin to fill this gap in our understanding of I/UCRC sustainability. Further, a better understanding of the sustainability process for demonstration projects and other CRC programs may be generalized from the case of I/UCRCs.

## *LITERATURE REVIEW*

There is great diversity in the literature on what is meant by program sustainability. However, the most widely cited sustainability theory was presented by Shediac-Rizkallah and Bone (1998). These authors synthesized literature from public health, organizational change and innovation, and community development research. Based on these divergent perspectives, program sustainability is defined as the continuation of program benefits, activities, and support structures beyond the end of initial funding.

Although a detailed review of the general and the CRC sustainability literature is beyond the scope of this paper, it suggests several barriers to and facilitators of sustainability that can be categorized at the environmental, organizational, program, and individual level (Shediac-Rizkallah & Bone, 1998; Adelman & Taylor, 2003; Scheirer, 2005; Ailes et al., 2000; Mujumdar, 2005; Julian & Kombarakaran, 2006; Stevens & Peikes, 2006; Johnson et al., 2004; Williams, Labonte, Randall, & Muhajarine, 2005; Goodman & Steckler, 1989; Mayer & Davidson, 2000). At the environmental level, a program's long-term sustainability can be influenced by: whether or not the program fits with the current sociopolitical climate, availability of alternative funding, economic trends, and involvement of outside stakeholders. At the organizational level sustainability can be influenced by: organizational strength in terms of maturity and resources, organizational stability, fit with the organization's mission and structure, and leadership or a strong program champion One study reviewed by Scheirer (2005) found that the "silo" structure of academic institutions had a negative impact on program sustainability (Harris et al., 2003 cited in Scheirer, 2005). However, with the increasing role of industry and government funding for research in academia, universities are beginning to embrace the triple helix model (Etzkowitz, Webster, Gebhardt & Terra, 2000).

At the program level, sustainability can be influenced by: stakeholder participation in program design, alignment with stakeholder needs, balance between program adaptability and fidelity to core program components, and the nature of funding. While several authors discussed the role of leadership or a strong program champion as an organizational variable I believe program champion can be treated as an individual variable (Howell & Boies,

2004; Howell & Shea, 2001). The CRC literature suggests the behavior of these individuals may be important (Ailes et al., 2000; Mujumdar, 2005; Craig et al., 2007).

Beyond defining sustainability and identifying predictor variables, the literature raises some methodological considerations regarding the study of program sustainability including: going beyond measuring whether the program simply exists; type of data collection; number of informants; timing of data collection and adequacy of statistical analyses (Scheirer, 2005).While the current study cannot overcome all the limitations found in previous literature, I took a longitudinal approach, used multivariate statistics, used multiple measures of sustainability, collected data from more than one respondent per Center, and controlled for variation in the timing of data collection.

## METHODS

### *Research Questions*

This study addressed the following research questions:

*Descriptive Questions*

1. What is the status of I/UCRCs after their grants end?
2. To what extent has the Center sustained itself in terms of continued program activities structures, and outcomes?

*Predictive Questions*

3. What environmental, organizational, program, and individual variables predict Center status?
4. What environmental, organizational, program, and individual variables predict Center sustainability as measured by continued activities, structures, and outcomes?

### *Research Design*

The study design is both descriptive and predictive. Questions one and two address current center operations, while questions three and four rely on data from the last year of the Centers' I/UCRC grant for predictive analysis. Data were obtained from archival records, surveys, and interviews with key Center informants.

*I/UCRC Program*

*Program Goals & Objectives.* The NSF I/UCRC program has been operating since 1979. Centers are semi-autonomous research organizations housed within a university setting (often with multiple university sites) that act as industry-university linkage mechanisms to engage in multidisciplinary collaborative research, in which research is directed by industrial interest (Gray & Walters, 1998). Collaboration with multiple industrial members means that Centers must focus on precompetitive research of interest to an industry, rather than specific member firms.

I/UCRCs are awarded a five-year grant of approximately $70,000 per year. They must maintain $300,000 of industrial support from at least six members and have a plan for self-sufficiency from the NSF[1]. This grant can be extended for an additional five years at a reduced funding level[2]. On average, I/UCRCs are funded for 10.84 years (*SD* = 5.42).

One of the main goals of the I/UCRC program is to foster long term partnerships that will be sustainable beyond NSF's involvement. In fact, the NSF explicitly states that its "investment in the I/UCRCs is intended to seed partnered approaches to new or emerging research areas, not to sustain the Centers indefinitely. The Foundation intends for I/UCRCs to gradually become fully supported by… other non-NSF sponsors" (National Science Foundation, 2006).

Since 1982, data have been collected to evaluate the degree to which I/UCRCs achieve these various goals and adhere to the collaborative process. As a result, a great deal is known about Centers while they are actively supported by the NSF. However, virtually nothing is known about post-NSF operations.

[1] A recent change in I/UCRC program requirements now states that new Centers must have 10 industrial members, with no minimum dollar amount specified. However, all of the Centers that are the focus of this study were subject to the old rules mentioned above.

[2] In the early years of the program, centers could restart their funding cycle by adding a new site or adjusting their research focus. There are still some centers that have been able to stay in the program by merging with newly formed centers under the new Center name. Based in part on preliminary results of this study NSF has instituted a Phase III award in which centers can receive funding for a third five years.

*Sample*

In order to participate, Centers must meet several criteria: 1) they must have received an NSF I/UCRC operating grant, 2) they are no longer funded by that grant, and 3) Centers whose grants ended and were subsequently funded because they merged with a newer Center were also included[3]. Centers must have also been out of the program for at least one year as of the 2006-2007 fiscal year[4].

There are 73 Centers that have exited the program; 43 single and 30 multisite centers (Gray & McGowen, 2008). Six Centers that merged with other IUCRCs to form three formerly funded I/UCRCs, bringing the total population to 70[5]. They range in age from 1 to 30 years old (See Figure 1).

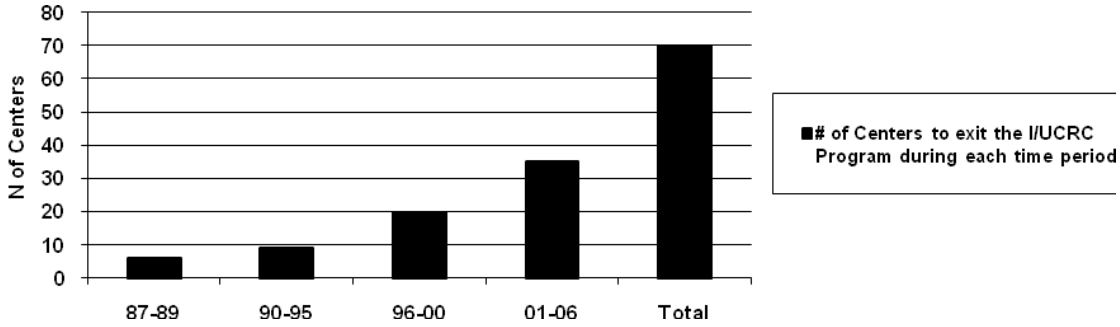


Figure 1. *Centers Exiting the I/UCRC Program by Year.*

Respondents were Center or university administrators. Because some Centers have been out of the program for as long as 22 years, it was often difficult to contact past administrators so a hierarchy of informants was developed: 1) current Director; 2) recent Director; 3), Director at the time of transition, 4) secondary Site Director, 5) University official to whom the Director reported, 6) anyone else at the university who was/is involved with the Center, and/or 7) university records and information available online. Of the 70 Centers in the sample 48.6% had the current Center Director as the primary key informant, 21.4% had a past Center Director, 2.9% had Center personnel, 4.3% had a university administrator, 4.3 had online sources, and 18.6% had multiple primary key informants. Of those with multiple key informants 15.7% included a current or past Center Director, while only 2.9% did not.

*Data Sources and Instruments*

Data came from archival data sources as well as semi-structured interviews and surveys administered to key informants. Archival data include an annually produced Center Director Structural Information Report, managing site university records, and other national level data sources. Center administrators or other key informants participated in an interview and completed a survey on outcome data. In the two instances that key informants declined to participate in the interview, they did provide the current status of the Center and directed the researcher to the Centers' websites for further information (participation rate = 100%).

*Procedures*

Respondent were invited via email to participate in the study. Calls and emails went out after one week to request an interview time. Follow-up contacts were made with non-responding participants to increase response rate.

[3] Merger with a newer Center is considered a sustainability strategy, and therefore should be captured in the analysis.
[4] There is not a generally agreed upon time period after which a program can be considered sustained. However, programs that have not dealt with issues of sustainability for at least one year have not reached a point at which accurate outcome data can be obtained.
[5] Graduation year data for merged centers was combined in all analyses.

*Measures*

*Post-Graduation Status.* Some Centers may sustain themselves for a period of time, but are not currently operating. As a result, participants were asked via the Key Informant Interview whether the Center operated for at least one year after the end of its I/UCRC grant (*post-graduation status)*.

*Current Status*. One of the most commonly used measures of sustainability is *current status* (Scheirer, 2005; Mujumdar, 2005). For this study, current status refers to whether or not a given Center exists as an industry-university research entity. This variable was assessed via the key informant interview by asking: "What happened to CENTER NAME after the I/UCRC grant ended?" Responses were coded as currently in operation or no longer in operation[6].

*Sustainability*

Program sustainability can be measured in terms of continued program activities, structures, and outcomes (Shediac-Rizkallah & Bone, 1998). For I/UCRCs this includes things such as conducting research, maintaining a budget, and publishing research. The variables measured via the Key Informant Interview and Survey for each of the sustainability categories are listed in Table 1 along with the coding scheme for each (descriptive statistics for these variables are presented in the results section).

[6] There are some minimum criteria against which Center status was gauged: conducts research, receives external support, involves at least 3 PIs, and at least 1 student involved. All sustained Centers met these minimum Center criteria. Those that did not were coded as not operating.

Table 1
*Sustainability measures and coding*

| Variable | Coding |
|---|---|
| Continued Activities | |
| Number of research projects | Count of Center projects in the most recently completed year |
| Change in research focus | 1) no change, 2) slight change, 3) some change, 4) a great deal of change, or 5) totally different |
| Continued Outcomes | |
| Number of intellectual property (IP) events | Count of inventions disclosed, licensing agreements, patent applications, patents granted, inventions producing royalties, and software copyrights in the most recently completed year |
| Number of Center graduates (at the graduate level) | Count of center trained graduate students graduating in the most recently completed year |
| Number of Center graduates hired by Center members (at the graduate level) | Count of center trained graduate students hired by member firms in the most recently completed year |
| Number of publications and presentations | Count of publications and presentations acknowledging Center support during the most recently completed year |
| Continued Structures | |
| Number of industry members | Count of member firms in the center in the most recently completed year |
| Number of faculty researchers | Count of faculty researchers in the center in the most recently completed year |
| Number of students involved | Count of undergraduate and graduate students involved in center research in the center in the most recently completed year |
| Number administrative personnel | Count of administrative personnel in the center in the most recently completed year |
| University overhead discount | The typical overhead rate charged by the managing university to grants and contracts minus the rate charged to membership fees in the most recently completed year |
| Total budget | Total dollar value of the center budget in the most recently completed year |
| Funding sources | Count of funding source categories from which a center received support in the most recently completed year. Funding source categories include: membership fees, additional industry funding, NSF, other federal sources, non-federal sources, state, university, and other sources |
| Number of departments involved | Count of departments involved in the center in the most recently completed year |
| Membership fee level | The primary membership fee level charged to member firms in the most recently completed year |

*Predictor Variables*

Beyond measuring descriptive characteristics of I/UCRCs that have exited the program, it was also important to measure environmental, organizational, program, and individual level variables that predict these outcomes. Predictor variables came primarily from archival and outside data sources and reflect the final year (graduation year) during which the Center was funded under the I/UCRC grant. Table 2 lists predictor variables by domain and indicates the source of data for each variable.

Table 2
*Predictor Variables, Descriptive Statistics, & Data Sources*

| Variable | Mean (SD) | Data Source |
|---|---|---|
| Environmental Level | | |
| US GDP | $9,696.44B ($2,477.32B) | Officer and Williamson (2006) |
| US R&D spending | $520.19B ($64.88B) | Science and Engineering Indicators |
| US industry outside spending on R&D | $160.10B ($47.51B) | Science and Engineering Indicators |
| US R&D spending in academia | $32.14B ($10.56B) | Science and Engineering Indicators |
| Organizational Level | | |
| Overhead discount | 31.73% (22.28%) | Center Director Report archival database |
| In-kind support ($100K) | $1.23 ($ 2.95) | Center Director Report archival database |
| Percent university funding to the Center | 8.82% (12.66%) | Center Director Report archival database |
| Managing univ. annual R&D expend. | $242.03M ($188.17M) | Science and Engineering Indicators |
| Industry support to the managing univ. | 8.94% (7.37%) | Science and Engineering Indicators |
| University type | 22.9% private, 34.3% public, 42.8% land-grant | Carnegie Foundation Classifications System |
| Carnegie classification | 2.9% MS, 2.9% Large MS, 2.9% Doc. research, 32.9% High Res., 57.1% Very High Res. | Carnegie Foundation Classification System |
| Program Level | | |
| Graduation status | 63% graduated, 37% not graduate | Center Director Report archival database |
| Total funding ($100K) | $10.36 ($10.98) | Center Director Report archival database |
| Number of university partners | 1.57 (.90) | Center Director Report archival database |
| Number of funding categories | 3.61 (1.29) | Center Director Report archival database |
| Number of members | 15.22 (23.83) | Center Director Report archival database |
| Number of faculty | 9.82 (7.50) | Center Director Report archival database |
| Number of administrative staff | 1.97 (1.59) | Center Director Report archival database |
| Number of students (grad&undergrad) | 13.44 (11.26) | Center Director Report archival database |
| Individual Level | | |
| Director administrative time allocation | 26.06% (22.95%) | Center Director Report archival database |
| Director research time | 32.46% (18.83%) | Center Director Report archival database |

The literature on program sustainability suggests that characteristics of the larger environment within which a program operates have an impact on potential for future sustainability (Shediac-Rizkallah & Bone, 1998; Scheirer, 2005). In the case of I/UCRCs, the most relevant environmental variables relate to economic trends in research and development. The literature also indicates that organizational characteristics impact program sustainability (Shediac-Rizkallah & Bone, 1998; Scheirer, 2005). Organizational level predictors refer to characteristics of the managing university site for a Center. Program level predictors are characteristics of the Centers themselves in their last year of the I/UCRC grant. Finally, individual level predictors refer to characteristics of key individuals involved with the Center; specifically the Center Directors. These predictors were intended to measure individual level variables during the final year of I/UCRC grant support.

## RESULTS

### *Descriptive Questions*

#### *Research Question 1: Center Status*

Center status was measured in terms or whether the center survived beyond the end of its grant (*post-graduation status*) and whether it is operating now (*current status*). Centers that operated for at least one year post-I/UCRC funding were considered to be sustained post-graduation. Over seventy-five percent of I/UCRCs are sustained post-graduation (N = 53). However, of the 70 formerly funded I/UCRCs 62.9% are currently operating (N = 44).

Table 3
*Center Status Measures*

| | N | % |
|---|---|---|
| Post-graduation status | | |
| Sustained | 53 | 75.7 |
| Not sustained | 17 | 24.3 |
| Current status | | |
| Operating | 44 | 62.9 |
| Not operating | 26 | 37.1 |

N = 53

*Research Question 2: Continued program activities, structures, and outcomes*

In addition to looking at whether a Center continues to operate beyond the end of its grant (Center status), the literature on program sustainability suggests that it is important to consider continued program activities, structures, and outcomes as indicators of sustainability (Scheirer, 2005). Descriptive statistics for the variables in each of the sustainability categories are listed in Table 4. In order to provides a benchmark for evaluating activities, structures and outcomes of these Centers data from currently funded I/UCRCs are included.

Centers could not be compared on continued activity measures because those data are not routinely collected for actively funded I/UCRCs. The average sustained Center conducts nearly 15 projects annually. In general, sustained Centers tend to make changes to their research focus that are categorized between slight and some change ($M = 1.59$, $SD = 1.04$)[7].

In terms of continued structures and outcomes, means and standard deviations are presented in Table 4. A MANOVA indicated that formerly funded I/UCRC were not significantly different from active I/UCRCs in terms of continued structures ($F(1, 71) = 1.01$, $p < .44$, $\eta^2 = .11$) or continued outcomes ($F(1, 57) = 1.88$, $p < ..13$, $\eta^2 = .12$)[8].

[7] Research focus was coded on a five point scale with zero indicating no change and four indicating a totally different research focus.
[8] Number of departments was excluded from the comparison of continued structures between formerly and actively funded centers because those data are not routinely collected for actively funded I/UCRCs.

Table 4
*Descriptive Statistics for Continued Program Activities, Structures and Outcomes for Sustained Centers Compared to Actively Funded I/UCRCs*

| | Sustained Centers | | | Currently Funded I/UCRCs | | | | |
|---|---|---|---|---|---|---|---|---|
| | *N* | *M* | *SD* | *N* | *M* | *SD* | *df* | *F* |
| Continued Activities | | | | | | | | |
| Research focus change | 44 | 1.59 | 1.04 | -- | -- | -- | -- | |
| Research projects | 36 | 14.92 | 13.30 | -- | -- | -- | -- | |
| Continued Structures | | | | | | | | 1.01 |
| N of members | 45 | 74.20 | 391.37 | 37 | 18.78 | 15.35 | 80 | |
| N of faculty | 44 | 14.91 | 12.74 | 37 | 12.78 | 10.15 | 79 | |
| N of students involved | 44 | 29.98 | 32.40 | 37 | 32.54 | 30.44 | 80 | |
| N of administrative staff | 41 | 1.73 | 1.90 | 37 | 1.95 | 1.39 | 76 | |
| Overhead discount % | 39 | 35.33 | 22.61 | 37 | 37.72 | 17.78 | 71.58 | |
| Total budget ($Mill) | 43 | 2.44 | 4.07 | 37 | 1.70 | 1.70 | 78 | |
| N of funding source categories[9] | 43 | 3.23 | 1.84 | 37 | 3.22 | 1.93 | 78 | |
| N of dept. involved | 42 | 3.43 | 1.52 | -- | -- | -- | -- | |
| Membership fee level($K) | 33 | 41.64 | 14.28 | 37 | 39.54 | 10.93 | 68 | |
| Continued Outcomes | | | | | | | | 1.88 |
| IP | 39 | 3.51 | 5.07 | 37 | 2.22 | 4.01 | 74 | |
| N of graduate students graduating | 35 | 11.20 | 15.47 | 37 | 7.89 | 7.99 | 70 | |
| N of graduate students hired by members | 30 | 5.27 | 5.87 | 37 | 2.00 | 4.62 | 65 | |
| Publications and presentations | 38 | 62.97 | 70.89 | 37 | 50.03 | 37.46 | 56.48 | |

*$p < .05$

*Predictive Questions*

Prior to running any predictive analyses, predictor and outcome variables were screened for outliers, multicollinearity, and missing data[10]. Logistic regression was used for categorical dichotomous outcome measures and linear regression was used for continuous outcome measures. Given the exploratory nature of this study, a trimming approach was used for the regression analyses, in which variables with a significant bivariate correlation with the outcome variable were retained for domain level analyses (Tabachnick & Fidell, 2001). Those that were significant at the domain level were included in the full model analysis. A statistical significance of $p < .10$ was employed because the limited sample size limits power and increases Type II error.

*Research Question 3: Predicting Center Status*

*Post-graduation status* was predicted by graduation year budget. For every $100K in graduation year total budget, the odds of a Center being sustained post-graduation increases by 13%. The full model logistic regression was significant (Model $\chi^2$ (2) = 9.59, $p < .01$), accounting for 21% of the variance in post-graduation status.

[9] It should be noted that sustained centers reported on funding received from eight categories (membership fees, additional industry funding, NSF, other federal sources, non-federal sources, state, university, and other sources). In addition to the 8 funding categories listed above, currently funded I/UCRCs also report data about I/UCRC grant funding. That category was eliminated from the counts given that sustained centers no longer funded by the I/UCRC program are categorically prevented from obtaining funding from that source.
[10] For a detailed description of data cleaning measures and variable screening methods used, please refer to McGowen (2010).

Table 5
*Logistic Regression Predicting Post-graduation Status*

| | Bivariate Exp(B) | Domain Exp(B) | Full Model Exp(B) | Tolerance | VIF |
|---|---|---|---|---|---|
| Program Level | | | | | |
| Graduation status | 3.62** | 2.65 | -- | -- | -- |
| budget ($100K) | 1.14** | 1.13** | 1.13* | .86 | 1.16 |
| Organizational Level | | | | | |
| overhead discount % | 1.03** | 1.03** | 1.02 | .86 | 1.16 |
| | | Nagelkerke $R^2$: .21 | | | |
| | | Model $\chi^2$ (2): 9.59*** | | | |

*$p < .1$, **$p < .05$

*Current Status* was predicted by graduation year members and graduation year US industry support for outside research. Given that Centers have graduated from the I/UCRC program over the course of the last 25 years, it may be that time since graduation is associated with current status. Therefore the regression was conducted, controlling for years since graduation. The full model was significant (Model $\chi^2$ (3) =28.35, $p < .01$), accounting for 46% of the variance (Nagelkerke $R^2 = .46$). For each additional member in the year of graduation, the odds of being currently sustained increase by 10%. Every billion dollars spent by industry for research performed elsewhere in the year of graduation increases the odds of the Center being currently sustained by 7%.

Table 6
*Logistic Regression Predicting Current Status Controlling for Years Since Graduation*

| | Bivariate Exp(B) | Domain Exp(B) | Full Model Exp(B) | Tolerance | VIF |
|---|---|---|---|---|---|
| Years since graduation | .81*** | | 1.14 | .03 | 30.28 |
| Individual Level | | | | | |
| director research time | .97** | 1.00 | -- | -- | -- |
| Program Level | | | | | |
| Graduation status | .12*** | 2.05 | -- | -- | -- |
| budget ($100K) | 1.12*** | 1.12 | -- | -- | -- |
| member Count | 1.08** | 1.09* | 1.10*** | .98 | 1.02 |
| admin. Staff | .70** | .72 | -- | -- | -- |
| Environmental Level | | | | | |
| US Industry Support for Outside Research ($1Bill) | 1.03*** | 1.08** | 1.07* | .03 | 30.27 |
| | | | Nagelkerke $R^2$: .46 | | |
| | | | Model $\chi^2$ (3): 28.35*** | | |

***$p < .01$. **$p < .05$. *p < .1

*Research Question 4: Predicting continued activities structures, and outcomes*

Since continued activities, structures, and outcomes data only apply to Centers that were sustained for at least one year, analysis is limited to those Centers (N = 53). Predictive analyses were conducted for select outcome variables from each category. Because this question addresses multiple outcome measures, intercorrelations were examined due to the potential for Type I error (See McGowen, 2010, Appendix G). Since some of the outcomes measures were correlated, a more strict p-value was used to reduce the potential for Type I error ($p < .05$).

*Continued Activities*. Number of research projects was regressed onto each predictor variable, but no significant predictors were identified.

*Continued Structures*. Number of members in the most recently completed fiscal was predicted by graduation year member count, accounting for 54% of the variance (Table 13). Centers with more members at the time of graduation have more members currently.

Table 7
*Predicting Current Members*

| | Full Model | | Tolerance | VIF |
|---|---|---|---|---|
| | B | *B* | | |
| Program Level | | | | |
| budget ($100K) | .24 | .18 | .57 | 1.75 |
| member count | .89* | .79 | .51 | 1.95 |
| graduate students | -.23 | -.20 | .39 | 2.56 |
| Intercept | 3.84 | | | |
| | | | $F(3, 40) = 17.69$* | |
| | | | $R = .76$ | |
| | | | $R^2 = .57$ | |
| | | | *Adjusted* $R^2 = .54$ | |

*$p < .01$

Budget in the most recently completed fiscal year was regressed onto each predictor variable[11]. In the final model graduation year member count was retained, accounting for 15% of the variance in current budget. Centers with more members in the year of graduation have higher current budgets.

Table 8
*Predicting Current Budget*

| | Bivariate | | Full Model | | Tolerance | VIF |
|---|---|---|---|---|---|---|
| | *B* | *β* | *B* | *β* | | |
| Program Level | | | | | | |
| budget ($100K) | .65** | .32 | -- | -- | .57 | 1.75 |
| member count | .80*** | .40 | .80*** | .42 | .51 | 1.95 |
| graduate students | .68** | .37 | -- | -- | .39 | 2.56 |
| Intercept | | | 7.40 | | | |
| | | | $F(1, 40) = 8.30$*** | | | |
| | | | $R = .42$ | | | |
| | | | $R^2 = .17$ | | | |
| | | | *Adjusted* $R^2 = .15$ | | | |

*$p < .1$, **$p < .05$, ***$p < .01$

*Continued Outcomes*. Number of IP events in the most recently completed fiscal year was entered regressed onto each predictor variable[11]. In the final model graduation year university expenditures on R&D was retained, accounting for 11% of the variance in current IP events. Centers with more graduation year university expenditures on R&D have fewer current IP events.

[11] Using a simultaneous entry method for regression analysis yielded a significant overall model, but none of the predictors accounted for significant unique variance. This is likely due to intercorrelation among predictors. However, correlation among predictors was not high enough to warrant elimination of any of the predictors and collinearity diagnostics did not fall within the range discussed in Field (2009) as indicating a collinearity problem. Therefore a full model regression using the backward entry method was performed to determine if any of the predictor variables could be retained. See McGowen (2010) for full details.

Table 9
*Predicting Current IP Events.*

| | Bivariate | | Full Model | | Tolerance | VIF |
|---|---|---|---|---|---|---|
| | *B* | *β* | *B* | *B* | | |
| Program Level | | | | | | |
| number of funding source categories | 1.14** | .33 | -- | -- | .86 | 1.16 |
| Organizational Level | | | | | | |
| university expenditures on R&D | -.008** | -.37 | -.008** | -.37 | .86 | 1.16 |
| Intercept | | | 1.14 | | | |
| | | | $F(1, 34) = 5.33$** | | | |
| | | | $R = .37$ | | | |
| | | | $R^2 = .14$ | | | |
| | | | *Adjusted* $R^2 = .11$ | | | |

***$p < .01$. **$p < .05$ *p < .1

Number of current Center graduate students graduating was predicted graduation year number of students involved, accounting for 37% of the variance. Sustained Centers with more students involved in the year of graduation have more current graduate students graduating.

Table 10
*Predicting Current Graduate Students Graduating*

| | Bivariate | | Full Model | | Tolerance | VIF |
|---|---|---|---|---|---|---|
| | *B* | *β* | *B* | *β* | | |
| Program Level | | | | | | |
| Grad year budget ($100K) | .45** | .41 | .05 | .05 | .57 | 1.76 |
| Grad year graduate students | .68*** | .61 | .66*** | .60 | .57 | 1.76 |
| Intercept | | | .26 | | | |
| | | | $F(2, 31) = 10.49$*** | | | |
| | | | $R = .64$ | | | |
| | | | $R^2 = .40$ | | | |
| | | | *Adjusted* $R^2 = .37$ | | | |

*$p < .1$, **$p < .05$, ***$p < .01$

## DISCUSSION

The goal of this study was to determine the extent to which formerly funded I/UCRCs are sustained and what factors predict their post-funding sustainability. The issue of post funding program sustainability is not unique to I/UCRCs. Government programs are often funded by grants that support their initial development. However, many times, these programs are expected to become self-sufficient. Little research exists about how these programs are able to accomplish this once their initial grants end. This study was a first step towards beginning to fill this gap in understanding I/UCRC sustainability.

### *Center Status*

Previous studies on program sustainability reported that between 20% and 80% of sites achieved some level of sustainability (Scheirer, 2005). Formerly funded I/UCRCs exhibit similar rates of sustainability with 75% sustained. Current status for formerly funded I/UCRCs measures fall more squarely in the middle, with about two-thirds sustained. Given that some Centers have been operating for 30 years and sustained for as long as 20 years, it seems fair to say that a high level of sustainability has been achieved by the I/UCRC program.

*Continued Activities, Structures, & Benefits*

The theoretical literature on program sustainability suggests that it is not enough to simply ask whether or not a program continues to exist (Goodman & Steckler, 1989; Shediac-Rizkallah & Bone, 1998). In terms of program activities, the present study found that formerly funded I/UCRCs report continuing to conduct research, and doing so in much the same vein as they were while I/UCRC grant funded. In terms of continued program structures and continued program outcomes, sustained Centers continue to be very successful and were not significantly different from actively funded I/UCRCs.

*Predicting Center Status*

While post-graduation status was associated with graduation status, graduation year budget, and graduation year overhead discount in bivariate logistic regressions, only budget was significant in the full model, with each additional $100K increasing the odds of being sustained by 13%. This finding supports previous studies on program sustainability in other areas of research. Much of the literature on program sustainability either conceptualized sustainability as synonymous with finding alternative funding or mentioned it as a significant predictor (Scheirer, 2005).

Current status, controlling for years since graduation, was predicted by graduation year number of members and US industry support for outside research. These two predictors reinforce the idea that outside stakeholder support is critical to program sustainability. US industry support for outside research can be considered a general measure of how much support industry is providing to other research sectors. This is precisely the funding that I/UCRCs rely on. It should be noted that this was measured for the year of graduation, yet it still predicts current status. These results indicate that graduation is a critical transition point. The economic environment during that time impacts Centers' ability to navigate the transition away from I/UCRC support. This finding is consistent with studies reviewed by Scheirer (2005) who reported that alternative funding was predictive of program sustainability. It is also supported by historical data from the I/UCRC program which shows the number of members leaving exceeding the number of members joining Centers in times of US economic recessions (Gray & McGowen, 2010). Therefore, it is recommended that the NSF consider providing bridge funding to Centers scheduled to graduate during recession periods in order to protect their investment until the economic environment rebounds enough for the Centers to survive. Based in part on preliminary findings from this study, NSF has begun to offer Phase III support. According to their website, "Phase III award provides a third five-year award for centers that demonstrate their viability, sustainability, and which have had a significant impact on industry research... Centers are expected to be fully supported by industrial, other Federal agencies, and state and local government partners after fifteen-years as an I/UCRC" (NSF website, 2010).

*Predicting Continued Activities, Structures, & Outcomes*

Predictive analysis was not able to account for variation in program activities as measured by number of research projects. Ailes et al. (2000) indicated that research projects are an important measure of program sustainability for CRCs. However, it may not be the number of projects conducted that is important but rather quality or type of research. Future research on program sustainability for CRCs would benefit from exploring more measures of continued program activities.

Graduation year number of members was the only variable that predicted continued program structures. It accounted for 54% of the variance in current members and 15% of the variance in current budget. The importance of member participation to continued program structures is not surprising given that I/UCRCs are built around fostering collaborative relationships with industry. This finding is also supported by the literature on program sustainability indicating that stakeholder support is key to program sustainability.

Predictive analyses for continued program benefits indicated that current IP events had a negative association with graduation year university expenditures on R&D. This is an unexpected finding warranting further research. Waugaman and Tornatzky (2001) found that universities that performed less research were able to achieve a high level of IP events when controlling for university research budget. It may be that, while larger universities have more funding for research, their focus tends to be more on basic research which is not typically IP focused. At the same time, smaller universities may be working to catch up by pursuing applied research and economic development which is more suited to IP. Alternatively, it may be that IP events is a poor measure of continued activities as several key informants mentioned that they do not pursue it, preferring to let their industrial partners pursue any IP. Given that the I/UCRC model emphasizes precompetitive research, this does make some sense.

Continued benefits were also measured by number of Center trained graduate students graduating. Only the number of students supported at the time of graduation was predictive, accounting for 37% of the variance. This result is intuitive for Centers that graduated from I/UCRC support recently. Those students that were being supported at the time of graduation may be the same students that are graduating currently. More broadly, Centers with a good track record of training students are more likely to continue to produce Center graduates.

*Limitations*

This study had several limitations that are worth mentioning. First, it relied in part on retrospective outcome data. An attempt was made to correct for this problem by using archival data sources. However, this limited the selection of predictor variables to those that were available in archival data sources. Unfortunately, low response rate and missing data prevented inclusion of more organizationally and psychologically interesting predictors. Sample size was also a limiting factor for this study. Data were collected from every formerly funded I/UCRC, but there are only 70 total. This may have limited statistical power. This study could also have benefited from a control group of graduates of other cooperative research center programs, allowing for comparison in both descriptive and predictive findings.

*Future Directions*

There are several ways in which future research can contribute to a better understanding of program sustainability. Future studies on program sustainability would benefit from taking the life cycle approach to sustainability advocated by Scheirer (2005). By anticipating program sustainability as an ultimate outcome and collecting data throughout the course of the program, a better understand of the program sustainability process can be achieved. Future research would benefit from more in depth assessment of current Center operational models. Also, Craig et al. (2007) developed measures of center leadership for CRCs. Further work on understanding the role of leadership and program championship in sustainability would greatly add to the body of knowledge.

*Conclusion*

This study empirically showed for the first time in the I/UCRC program's history that the NSF has succeeded in its mission to foster long term relationships between industry and university. Second, it also took some important first steps toward quantifying the level of sustainability achieved. Sustained Centers provide a very large indirect impact for the I/UCRC Program, nearly doubling NSFs investment leveraging from eight to one to fifteen to one (McGowen & Gray, 2009). In addition, this study is the first to empirically assess factors associated with CRC program sustainability. It was able to predict sustainability and related measures to a substantial extent, showing that program sustainability is related to funding, economic factors in the environment, and stakeholder involvement. It is hoped that these results can be used by the program stakeholders to prepare for self-sustainability. In particular, Center Directors are encouraged to actively pursue funding opportunities for their Centers and to focus on maintaining close relationships with industry. This will help ensure they have the funds and stakeholder support to continue operating. Based on the results of this study, NSF is encouraged to continue to emphasize the importance of stakeholder support. NSF is also encouraged to consider providing bridge funding to Centers scheduled to graduate during economic recessions. There is still a need for further investigation of program sustainability, both generally and for CRCs. This study was a first step toward that goal.

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