Industry/University Cooperative Research Centers

Predictors of Cooperative Research Centers Post-Graduation Success

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IUCRC Evaluation Project

Outline

Industry/University Cooperative Research Centers

- Background and Recap on Previous Findings
- Predictive Results
  - All New!
- Exploratory Results
- Research Add-on's
- Next Steps

Background

Industry/University Cooperative Research Centers

- **Background**:
  - Federally supported research centers including IUCRCs are typically funded for a time-limited period ~ 10 years
  - Concerns about entitlement
- **What do we know about Center sustainability?**
  - General literature
    - » Modest literature primarily from public health literature
  - Centers
    - » Tiny, inconclusive literature based on ERCs
    - » IUCRC: no systematic information
  - Definition (Shediac-Rizkallah & Bone, 1998):
    - » Sustainability is continued program *activities*, continued *benefits* to stakeholders, & organizational *capacity* to continue to support the program once initial federal support is exhausted
  - Predictors
    - » Environmental, Organizational, Program, Individual
    - » Variables at each level should be tailored to the program
- Motivation:
  - Need to understand sustainability and factors that influence it

Purpose of Research

Industry/University Cooperative Research Centers

Describe

1. To determine the status of I/UCRCs post-funding - DONE
2. To determine how much fidelity to the I/UCRC model sustained centers exhibit - DONE
3. To determine the extent to which centers have sustained themselves in terms of continued program activities, structures, and outcomes - DONE

Predict

4. To determine what factors predict center status - NEW
5. To determine what factors predict fidelity to the IUCRC model - NEW
6. To determine what factors predict center sustainability - NEW

Explore

7. To determine what issues key informants think are critical for I/UCRC sustainability – NEW

Add-ons

8. To determine the indirect impact of the I/UCRC program achieved by graduated centers – DONE
9. Obtain an in-depth understanding of the processes involved in becoming a successful center – IN PROGRESS

Method

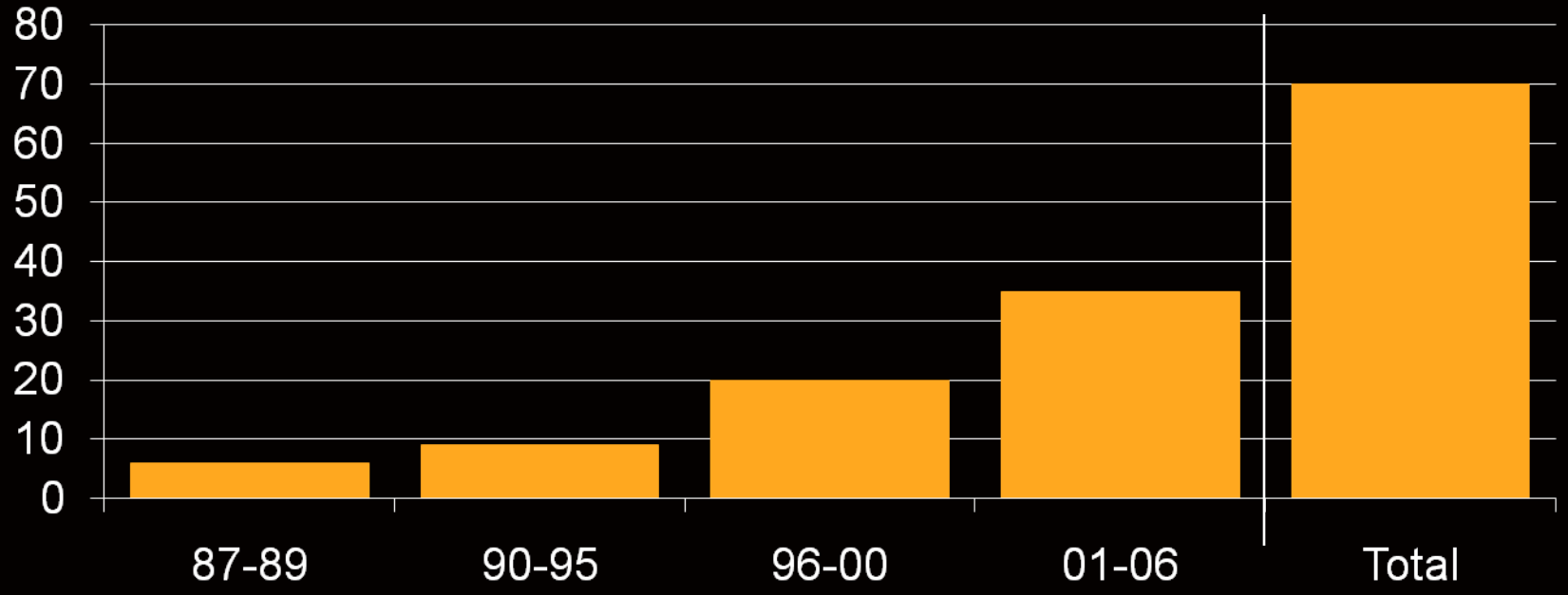
Industry/University Cooperative Research Centers

- Design
  - Descriptive & Predictive Correlational Design
    - » Time 1 → Time 2
      IVs DVs
- Participants
  - Sampling Criteria
    - » Center received an NSF I/UCRC operating grant
    - » Center no longer funded by an NSF I/UCRC operating grant
    - » Center graduated and merged with a newer Center
    - » Center has not received NSF I/UCRC money for at least 1 year
  - Respondents
    - » Key Informants
      - » 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 , 7) archival and online records

Sample

Industry/University Cooperative Research Centers

N of centers to exit the I/UCRC program during each time period



- Total N = 70
  - 73 Centers exited the program
  - 6 merged centers = 3 graduated
  - Center age = 1-30 years
  - 100% participation rate

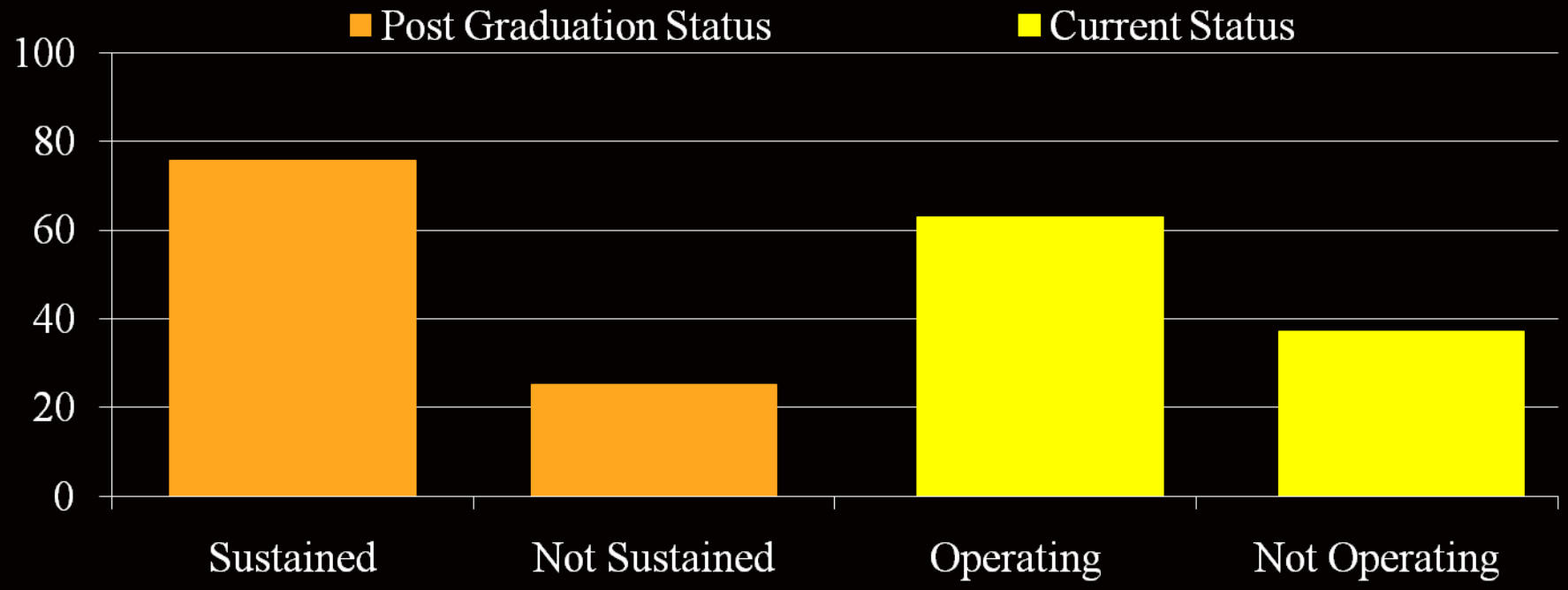
Results

Dependent Variables:

Quick Recap

Q1: What is that status of formerly funded I/UCRCs?

Industry/University Cooperative Research Centers



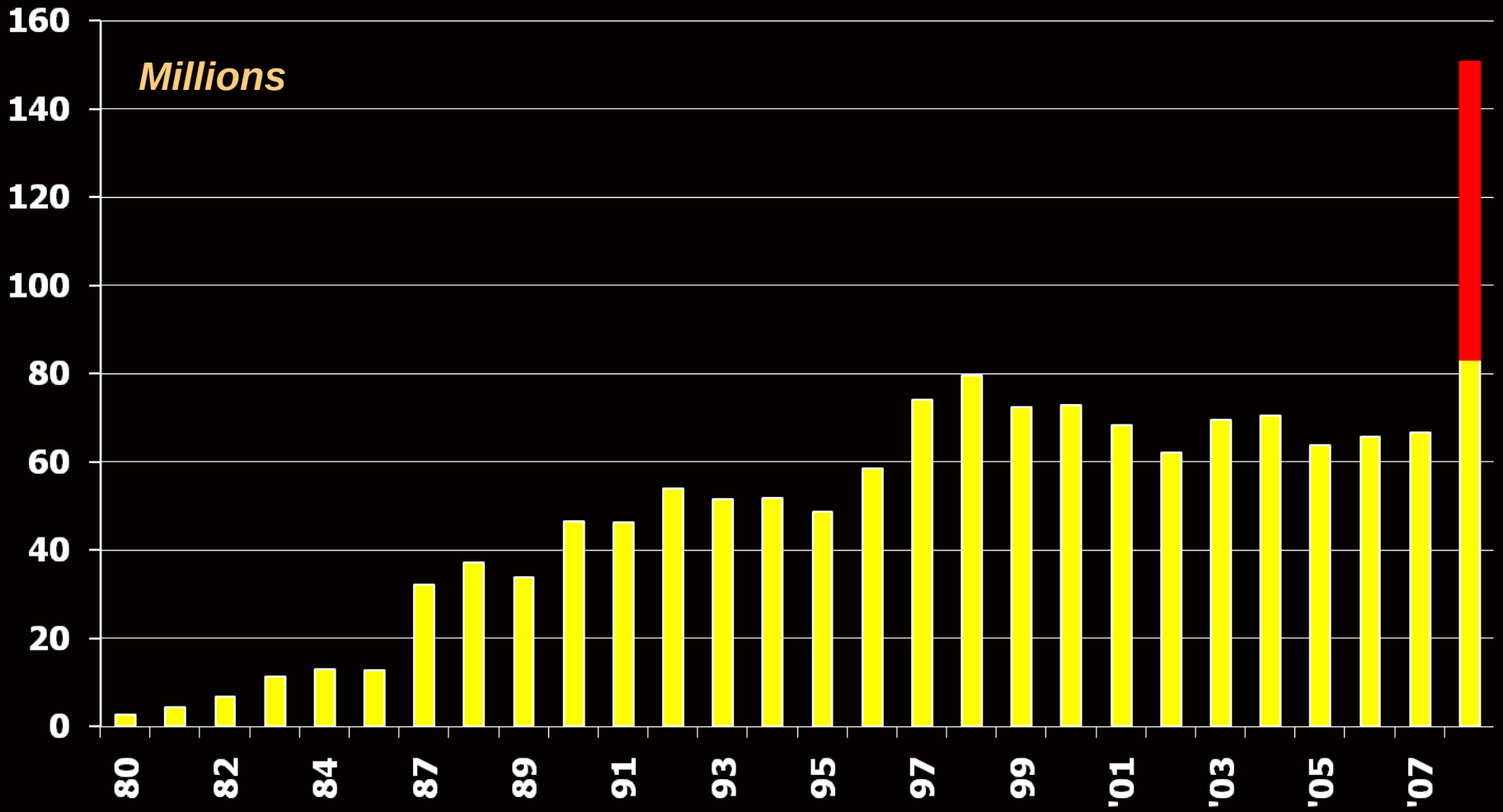
- Post-graduation status
  - 53 sustained
  - 17 not sustained
- Current status
  - 44 operating
  - 26 not operating

Q3: What level of sustainability do formerly funded centers achieve?

	Sustained Centers			Current I/UCRCs					
	N	***M***	*SD*	*N*	*M*	*SD*	*df*	*t*	*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	-.86	
N of faculty	44	**14.91**	12.74	37	12.78	10.15	79	-.82	
N of students involved	44	**29.98**	32.40	37	32.54	30.44	80	.37	
N of administrative staff	41	**1.73**	1.90	37	1.95	1.39	76	.56	
Overhead discount %	39	**35.33**	22.61	37	37.72	17.78	71.58	.51	
Total budget ($Mill)	43	**2.44**	4.07	37	1.70	1.70	78	-1.03	
N of funding source categories	43	**3.23**	1.84	37	3.22	1.93	78	-.04	
N of dept. involved	42	**3.43**	1.52	--	--	--	--	--	
Membership fee level($K)	33	**41.64**	14.28	37	39.54	10.93	68	-.69	
Continued Outcomes									1.88
IP	39	**3.51**	5.07	37	2.22	4.01	74	1.23	
N grad students graduating	35	**11.20**	15.47	37	7.89	7.99	70	1.15	
N grad students hired by members	30	**5.27**	5.87	37	2.00	4.62	65	2.55**	
Publications and presentations	38	**62.97**	70.89	37	50.03	37.46	56.48	-.99	

Program Level: Funding

Industry/University Cooperative Research Centers



Program level: Membership

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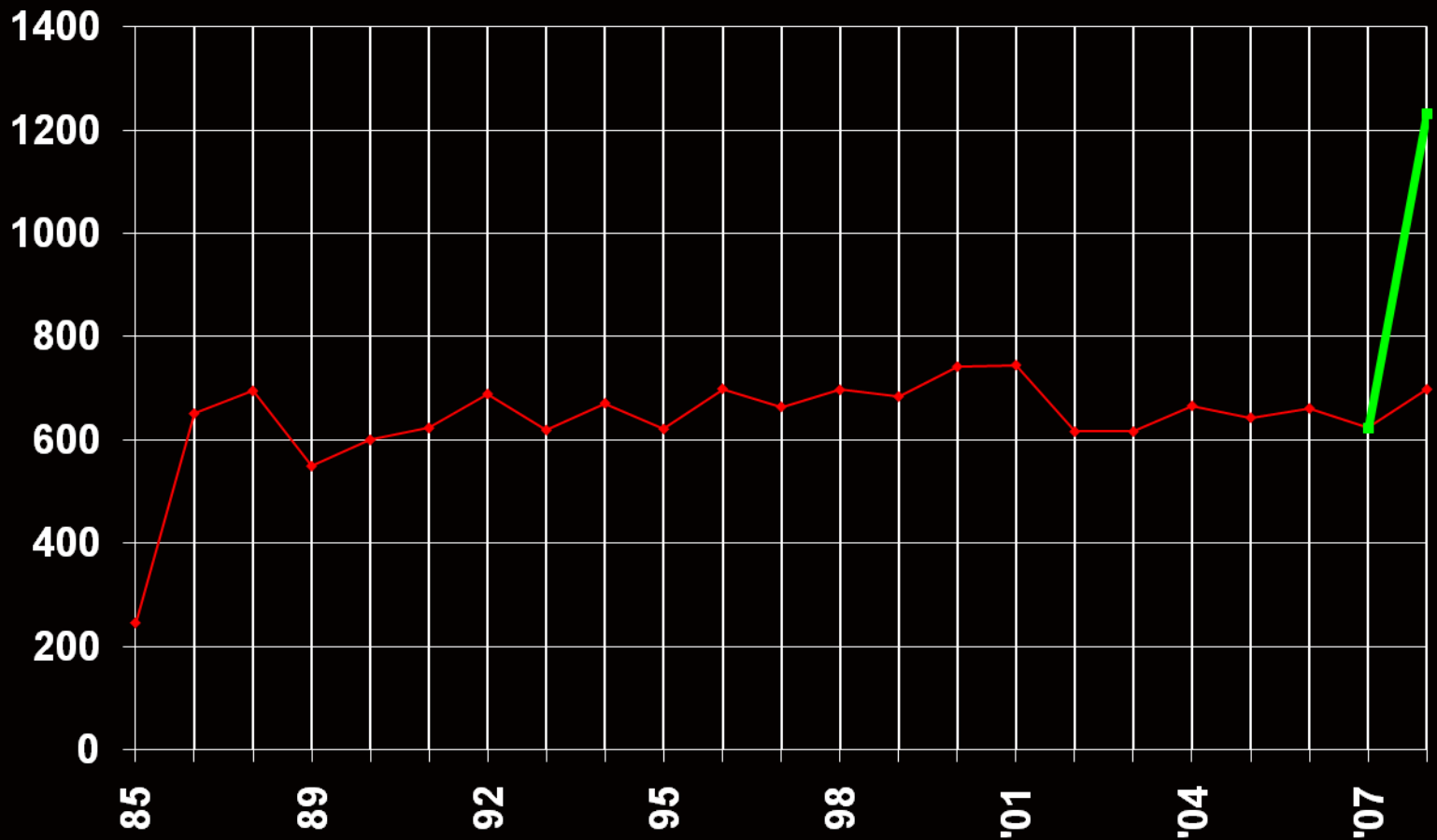
TOTAL NUMBER OF MEMBERS



*Does not include merged centers or those for which current member data is missing

Q2: How much fidelity to the I/UCRC model to formerly funded centers maintain?

Industry/University Cooperative Research Centers

	%
Core IUCRC Components	
industrial support	96.2
university based	94.3
stakeholder meetings	69.8
membership fees	67.9
IAB	67.9
consortial results dissemination	64.2
consortial project selection	50.9
Secondary IUCRC Components	
Tech Transfer	94.3
Evaluator	17.0
LIFE	17.0

N = 53

- Industry support, university based, and tech transfer are almost universal across sustained centers

Fidelity EFA

Industry/University Cooperative Research Centers

	h^2	F1: Structure	F2: Assessment
stakeholder meetings	.70	.84*	.02
membership fees	.93	.94*	.20
IAB	.89	.93*	.16
consortial results dissemination	.89	.93*	.16
consortial project selection	.63	.76*	.23
Evaluator	.71	.15	.83*
LIFE	.76	.13	.86*
Eigenvalue		4.25	1.26
% Total variance explained		60.66%	18.00%
α		.93	.66
Mean		.75	.21
SD		.38	.36

As I've mentioned before, these measures of fidelity may not fully capture the various organizational forms and identity of formerly funded I/UCRCs….

Results

Predictive Questions

Some house keeping…

Industry/University Cooperative Research Centers

- Prior to running any predictive analyses predictor and outcome variables were screened for skewness/outliers and multicollinearity.
  - Skewness/outliers were a problem
    - » Transformations did not address the issue
    - » Recoded outliers to one unit greater than the next most extreme variable (Tabashnick & Fidell, 2001; Field, 2003)
  - Multicolliniarity was a problem for environmental predictors
    - » Variables were not allowed to correlate $r > .80$
      - » Dropped all but one of intercorrelated variable

Some house keeping…

Industry/University Cooperative Research Centers

- Trimming approach
  - Given the exploratory nature of this study, a trimming approach was used for the regression analyses (Tabachnick & Fidell, 2001).
    1. Bivariate regressions to identify all significant predictors of each outcome
    2. Significant bivariate predictors grouped by domain and tested using multiple regression analyses.
    3. All remaining significant predictors for each outcome combined in full model
  - A statistical significance of $p < .10$ was employed because the limited sample size limits power and increases Type 1 error.

Q4: What factors predict center status?

Industry/University Cooperative Research Centers

Logistic regression predicting post-graduation status

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

- Each additional $100K at the year of graduation increases the odds of being sustained for at least one year by 13%
- Accounts for 21% of the variance in post-grad status

Q4: What factors predict center status?

Industry/University Cooperative Research Centers

Logistic regression predicting current status

	Bivariate Exp(B)	Domain Exp(B)	Full Model Exp(B)
Individual Level			
Graduation year director research time	.97**	.97**	.98
Program Level			
Graduation status	8.50***	6.11**	3.65*
Graduation year budget ($100K)	1.12***	1.13*	1.16*
Graduation year member Count	1.08**	1.05	--
Graduation year admin. staff	.70**	.62*	.76
Environmental Level			
Grad Ind. Support for Outside Research ($1Bill)	1.03***	1.03***	1.02**
			Nagelkerke R^2: .53
			Model χ^2 (5): 33.30***

- Graduated centers are 3.65 times more likely to be currently operating
- Each add'al $100K at the year of grad increases the odds by 16%
- Each add'l $1Bill in industry support for outside research in the year of grad increases the odds by 2%
- Accounts for 53% of the variance in current status

Q4: What factors predict center status?

Industry/University Cooperative Research Centers

Logistic regression predicting current status **controlling for years since graduation**

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

- After controlling for years since graduation:
  - Each add'l member increases the odds by 10%
  - Each add'l $1Bill in industry support for outside research in the year of grad increases the odds by 7%
  - Accounts for 46% of the variance in current status

Q5: What predicts assessment fidelity?

Industry/University Cooperative Research Centers

	Bivariate		Full Model	
	B	*β*	*B*	*β*
Program Level				
Graduation year number of sites	.10**	.29	.08	.23
Graduation year budget ($100K)	.01**	.31	.009*	.25
Intercept			-.03	
			$F(2, 43) = 3.65$**	
			$R = .38$	
			$R^2 = .15$	
			Adjusted $R^2 = .11$	

- Centers with higher graduation year budgets also reported higher assessment fidelity.
- Accounting for 11% of the variance in assessment fidelity.

Q5: What predicts structural fidelity?

Industry/University Cooperative Research Centers

	Bivariate		Domain		Full Model	
	B	*β*	*B*	*β*	*B*	*β*
Program Level						
Graduation Status	.39***	.45	.32***	.37	.29**	.32
Graduation year budget ($100K)	.01**	.36	.008***	.20	.01***	.39
Graduation year member count	.01**	.35	.002	.05	--	--
Graduation year faculty	.03***	.43	.01	.24	--	--
Organizational Level						
Graduation year In-kind ($100K)	-.07**	-.34	-.07**	-.35	-.08***	-.37
Graduation year overhead discount %	.005**	.32	.003	.17	--	--
Graduation year university funding %	-1.05***	-.36	-.72	-.25	--	--
Intercept					.48	
					$F(3, 35) = 6.98$***	
					$R = .61$	
					$R^2 = .37$	
					Adjusted $R^2 = .32$	

- Graduated sustained centers had higher structural fidelity than did non-graduates.
- Sustained centers with higher grad year budgets also had higher structural fidelity.
- Centers with more in-kind support reported lower structural fidelity.
- Accounting for 32% of the variance.

Q6: What predicts continued structures - current members?

Industry/University Cooperative Research Centers

	Full Model	
	B	β
Program Level		
Grad year budget ($100K)	.24	.18
Grad year member count	.89*	.79
Grad year graduate students	-.23	-.20
Intercept	3.84	
	$F(3, 40) = 17.69$*	
	$R = .76$	
	$R^2 = .57$	
	Adjusted $R^2 = .54$	

- Centers with more members at the time of graduation also have more members currently.
- Accounting for 54% of the variance in current member count.

Q6: what predicts continued structures - current budget?

Industry/University Cooperative Research Centers

	Bivariate		Full Model: Enter Method		Full Model: Backward Entry Method	
	B	*β*	*B*	*β*	*B*	*β*
Program Level						
Grad year budget ($100K)	.65**	.32	.34	.17	--	--
Grad year member count	.80***	.40	.59	.31	.80***	.42
Grad year graduate students	.68**	.37	.34	.07	--	--
Intercept			4.61		7.40	
			$F(3, 38) = 3.36$**		$F(1, 40) = 8.30$***	
			$R = .46$		$R = .42$	
			$R^2 = .21$		$R^2 = .17$	
			Adjusted $R^2 = .15$		*Adjusted* $R^2 = .15$	

- Enter method model was significant but no predictors were → backward entry method.
- Centers with more members in the year of graduation have higher current budgets.
- Accounting for 15% of the variance in current budget.

Q6: What predicts continued outcomes – Current IP events?

Industry/University Cooperative Research Centers

	Bivariate		Full Model: Enter Method		Full Model: Backward Entry Method	
	B	β	*B*	β	*B*	β
Program Level						
Graduation year number of funding source categories	1.14**	.33	.73	.21	--	--
Organizational Level						
Graduation year university expenditures on R&D	-.008**	-.37	-.007*	-.29	-.008**	-.37
Intercept			2.51		1.14	
			$F(2, 33) = 3.43^{**}$		$F(1, 34) = 5.33^{**}$	
			$R = .42$		$R = .37$	
			$R^2 = .17$		$R^2 = .14$	
			Adjusted $R^2 = .12$		*Adjusted* $R^2 = .11$	

- Enter method model was significant but no predictors were → backward entry method.
- Centers with more graduation year university expenditures on R&D have fewer current IP events.
- Accounting for 11% of the variance in current IP events.

Q6: What predicts continued outcomes – Current graduate students graduating?

Industry/University Cooperative Research Centers

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

- Sustained centers with more students involved in the year of graduation have more current graduate students graduating.
- The full model accounted for 37% of the variance in current graduate students graduating.

Predictive Summary

Industry/University Cooperative Research Centers

	Post-grad status	Current status	Yrs. Operating fraction	Yrs. Sustained fraction	Assessment fidelity	Structural fidelity	Current projects	Current members	Current budget	Current IP	Current grad students graduating
Grad status		+	+	+		+					
Grad budget	+	+		+	+	+					
Grad members								+	+		
Grad students											+
Grad Univ. expenditures on R&D										-	
Grad in-kind						-					
Grad Industry support for outside research		+	+	+							

Q7: What issues do key informants think are critical for sustainability?

Industry/University Cooperative Research Centers

	% of respondents	% of responses
economic factors	**45.83%**	**11.52%**
pursuing new funding opportunities	**41.67%**	**10.47%**
close connection to member firms	**33.33%**	**8.38%**
meet industry needs: technical	**33.33%**	**8.38%**
University support	**31.25%**	**7.85%**
director commitment/persistence	**31.25%**	**7.85%**
meet industry needs: partnership format	**29.17%**	**7.33%**
research quality	**29.17%**	**7.33%**

N of respondents = 48; N of responses = 191

Discussion

Discussion

Industry/University Cooperative Research Centers

- This study was a first step towards beginning to fill this gap in understanding of I/UCRC sustainability.
- Results showed that the majority of formerly funded I/UCRCs are sustained and continue to provide considerable benefits and identified several predictive variables.
- Previous studies reported between 20% and 80% of sites sustained (Scheirer, 2005).
  - Formerly funded I/UCRCs exhibit very high rates of sustainability: 75% sustained.
  - Near the upper end on currently sustained: 62%
    - » Slightly less than the 80% estimate offered by NSF
  - But, this is an old program with some centers operating 30 years, sustained 20 – that's pretty darn good!

Discussion: Overview

Industry/University Cooperative Research Centers

- Descriptive results answer NSFs question, “what happens to these centers after we stop funding them?”
  - The answer is positive, for the most part they continue to operate and do so in much the same way as the did while they were funded and at a comparable level to actively funded I/UCRCs
- The most common predictors of the various measures of center sustainability were graduation year budget (5/11), graduation status (4/11), industry support for outside research (3/11), and graduation year members (2/11)
  - This basically indicates that sustainability relies on having the funding to keep the program going, having enough time to implement the program so it is institutionalized within the host organization, having the support of stakeholders, and an economic environment that is strong, especially at critical center transition points

Limitations

Industry/University Cooperative Research Centers

- Some retrospective outcome data
  - An attempt was made to correct for this problem by using archival data sources
- Selection of predictor variables was limited
- Missing archives and low response from evaluators prevented inclusion of some organizationally and psychologically interesting predictors
- Sample size was also a limiting factor for this study.
  - Every effort was made to maximize N. Data were collected from every formerly funded I/UCRC.
- No control group

Conclusions

Industry/University Cooperative Research Centers

- This study empirically showed for the first time in the I/UCRC program's 30 yr history that NSF succeeded in its mission to foster long term I/U relationships
- Quantifies sustainability for formerly funded centers
- Demonstrate indirect impact for the program, nearly doubling NSFs investment leveraging from eight to one to fifteen to one (McGowen & Gray, 2009).
- Fidelity results demonstrate the viability of the I/UCRC program model
- 1st to empirically assess factors associated with CRC sustainability.
- Provide some guidance NSF and directors of actively funded I/UCRCs to prepare for self-sustainability

Future Directions

Industry/University Cooperative Research Centers

- Take a life cycle approach to sustainability advocated by Scheirer (2005).
  - Anticipate data requirements prior to the end of the grant
- Measuring fidelity
  - Develop measures based on original model AND current operations
- Case studies underway
  - Program sustainability is a complex process that varies widely from center to center
  - It is a process that can not be fully understood via quantitative prediction
  - Need to get more qualitative understanding

Case Study Project

An in-depth look at some of the most successful graduated I/UCRCs

Case Studies
Gray, McGowen, Tornatzky

Industry/University Cooperative Research Centers

- Goal: Obtain an in-depth understanding of the processes involved in becoming a successful center
  - 4-6 cases; Selected for success, lessons learned, diversity
- Case Study Outline
  - Introduction
  - Early History and Background (launch to pre-transition)
    - » technical focus, strategic goals, key partners, organizational characteristics, leadership, major facilities/equipment, fidelity to the IUCRC model, key events, accomplishments
  - Evolution and Transitioning Phase
    - » challenges, model modifications, opportunities capitalized, transition planning
  - Achieving Self-Sufficiency
    - » Contemporary Profile, organization/structure, leadership, equipment/facilities, funding, key partners, accomplishments and events
  - Conclusions
- Data Sources
  - McGowen CD interviews, follow-up CD interviews, interviews with key stakeholders, evaluator reports, historical profiles (1984), CD archive, center generated materials

Selected Cases

Industry/University Cooperative Research Centers

- Advanced Steel Processing & Products Research Center
- Center for Advanced Communications
- Center for Umass Industry Research on Polymers (CUMIRP)
  - High fidelity plus organizational innovations, huge impact on host univ. industry partnering, one of the oldest IUCRCs
- Edison Welding Institute (EWI)
  - The most successful graduated IUCRC in terms of size of operation ($25M), operates as an independent research entity but still has connection to OSU
- Air Conditioning & Refrigeration Center (ACRC)
  - High fidelity, center continues to grow, research has evolved with industry needs, has a spin-off company
- Power Systems Engineering Research Center (PSERC)
  - Merged with ACEPS, maintained partnering with 13 universities, hot research area, has a spinoff company, has major DOD funding for shared research

Next Steps

Industry/University Cooperative Research Centers

- Celebrate Defense!
- Case Studies
  - Cases selected
  - Data Collection - In progress
  - Report at Jan 2011 I/UCRC Meeting

Acknowledgements

Industry/University Cooperative Research Centers

- Thank you to my committee for all your help
- Thank you Denis!
- Much support was provided by NSF, the I/UCRC program, and program evaluators
- Thanks to my lab mates too!

Discussion: Fidelity

Industry/University Cooperative Research Centers

- Just about everyone says program adaptability is an important part of sustainability
- Nearly all sustained centers are still university based, receive industrial support, and transfer technology to their stakeholders.
- Fidelity did not predict sustainability but…
  - Fidelity was high with not much variance
  - 75% structural fidelity; 21% assessment fidelity, but only made up of 2 items and has marginal reliability
- The propensity for sustained centers to make adaptations to the program model is consistent with previous work
- Mayer & Davidson (2000) argued that while it is important that programs can be modified to fit local conditions, it is equally important to maintain fidelity to core components if continued program benefits are to be achieved. Results of this study seem to indicate that this is the case for formerly funded I/ICURCs.
  - Had no measure of reinvention

Discussion: Sustainability

Industry/University Cooperative Research Centers

- It is not enough to just ask if the program still exists. (Goodman & Steckler, 1989; Shediac-Rizkallah & Bone, 1998).
- Different rates of sustainability reflected in different measures (Scheirer's, 2005).
- Sustained centers report continuing to conduct research (an average of 15 projects per year) in much the same vein as they were
- Sustained centers operate at the same level as actively funded centers in terms of continued structures.
- Same is true for continued outcomes. Graduated centers had sig. more students hired, but this may be due to the age of actively funded centers.

Discussion: Predicting Status

Industry/University Cooperative Research Centers

- Post-graduation status is predicted by grad year budget.
  - Consistent with the literature, which often conceptualized sustainability as synonymous with finding funding to support the program (Scheirer, 2005).
- Current status was predicted by grad status, budget, and US industry spending on outside research.
  - Graduated centers are better prepared for self-sustainability.
  - Literature supports this finding, stating that program implementation and length of initial funding are critical
  - Environmental level predictor is interesting because it is a measure of industry collaboration, which is the heart of the I/UCRC program
  - Also interesting because it highlights how critical graduation is as a point of transition for centers

Discussion: predicting assessment fidelity

- Assessment fidelity was predicted by grad budget
  - Small minority continue the assessment activities
  - Only accounted for 11% variance
  - Possibly due to marginal alpha for the scale

Discussion: predicting structural fidelity

Industry/University Cooperative Research Centers

- Graduation status, graduation year budget, and graduation year in-kind support predict structural fidelity.
  - Centers that complete their grants maintain their structure
  - Centers with more funding don't need to think about changing the way they operate, because it is working for them
  - In-kind negative relationship to structural fidelity is somewhat surprising – contradicts the literature (Scheirer, 2005)
  - It may the that in-kind support denotes less commitment from stakeholders than if they had contributed $
  - NSF seems to have recognized this in the limits they put on in-kind support for active centers

Discussion: predicting continued structures

Industry/University Cooperative Research Centers

- Graduation year number of members was the only variable that predicted continued program structures.
  - Highlights the importance of stakeholder participation mentioned in sustainability lit
  - Reinforces the I/UCRC program model, which is built around relationships with stakeholders

Discussion: predicting continued benefits

Industry/University Cooperative Research Centers

- Graduation year university expenditures on R&D had a negative relationship to current IP events
  - Unexpected finding warranting further research
  - May be a case of number two tries harder (Waugaman & Tornatzky, 2001)
  - May be that big research universities focus more on basic than applied research
- Or maybe IP is just a bad measure of continued benefits for I/UCRCs...

Discussion: predicting continued benefits

Industry/University Cooperative Research Centers

- Number of center trained graduate students graduating was predicted by number of students supported at the time of graduation
  - Seems pretty straight forward.
  - Past students supported are current students graduating
  - Or, centers that centers that regularly involve students have a good track record of producing well trained center graduates.

Discussion: Exploratory

Industry/University Cooperative Research Centers

- Most commonly mentioned factor, economics, was also sig. in quant analysis
- Pursuing new funding opportunities was supported by quant: budget → sustainability
- Same for close connection with members, this is also supported by previous work
- University cost sharing, leadership, faculty participation, research quality, did not play out in quant analysis, but was mentioned by other CRC studies – relationship may be more complex, maybe I didn't have enough power
  - Opportunity for future research