Non-Economic Approaches to Center Evaluation

There is still money on the table

Lindsey McGowen & David Meyer
Problem

• I/UCRCs are hard to create and run
  – Center Directors
  – Industry Members
  – NSF Directors
  – Evaluators
Solution

Show the value of hard work in I/UCRCs

(from: IUCRC Evaluation Team Logic Model, T. Berhrens et al. 2014)
But busy people get good at “winging it”
Busy people know how to make due
Need a vision of something better
Clear demonstration of WHY... Because I get “all that” for just $i (MY membership fee)!

The Center Ideal: Everyone’s utility is maximized

\[ \sum A_{center} \leq U_{max}(i...n) \]

Centers closer to this ideal include:

A = actions available to center
N = all agents with individual participant i
U = utility value
T = time, with moment in time (t-1)

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**Industry Sector Impacts, NSF IUCRC Investments since center inception**

<table>
<thead>
<tr>
<th>IUCRC investments &amp; Impacts</th>
<th>TOTAL</th>
<th>IMS</th>
<th>BSAC</th>
<th>CPaSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated impacts (present value)</td>
<td>$1267.1M</td>
<td>$846,738,946</td>
<td>$410,727,849</td>
<td>$9,638,633</td>
</tr>
<tr>
<td>Total investments (present value)</td>
<td>$19.6M</td>
<td>$3,133,857</td>
<td>$13,250,712</td>
<td>$3,203,057</td>
</tr>
<tr>
<td>Benefit:Cost Ratio</td>
<td>64.7:1</td>
<td>270.2:1</td>
<td>31.2:1</td>
<td>3.0:1</td>
</tr>
<tr>
<td>Net Present Value</td>
<td>$1247.5M</td>
<td>$843,605,090</td>
<td>$397,477,137</td>
<td>$6,435,577</td>
</tr>
</tbody>
</table>

- Realized impacts with a net present value of $1.25B.
Why and How

Why = Valuable Outcomes and Impacts
If estimate of benefits > sponsorship fee, sponsors know WHY they cooperate

\[
(T)S_i \leq \frac{\text{Research Benefits} + \text{Recruitment Benefits} + \text{Networking Benefits} \pm \text{“Other”}}{(t-1)}
\]

IUCRC program also provides guidance on HOW
Feedback Opportunities on “How”

• **Center Directors:**
  – meeting materials & best practices checklists
  – support among CDs network,
  – purple book,
  – NSF and evaluator feedback...

• **Industry**
  – Trusting relationship among industry,
  – learning from other members,
  – opportunity to identify and do research with risk-sharing,
  – able to do work otherwise couldn’t do,
  – strong working relationships with faculty and students,
  – professional and leadership development, increased prestige in company...
<table>
<thead>
<tr>
<th>Inputs</th>
<th>Activities</th>
<th>Outputs</th>
<th>Short-term Outcomes</th>
<th>Intermediate Outcomes</th>
<th>Long-term Outcomes</th>
<th>Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF Award: Funding &amp; Prestige</td>
<td>NSF planning meeting guidance and feedback</td>
<td>University/Faculty/Students</td>
<td>Increased capacity to attract $ funding for res.</td>
<td>University/Institutional</td>
<td>University/Institutional</td>
<td>Public Benefit: Enhanced research and innovation ecosystem</td>
</tr>
<tr>
<td>Best Practices: Technical Assistance, Bylaws and Membership Agreement</td>
<td>NSF I/UCRC directors meetings, boot camp</td>
<td>Technology roadmap</td>
<td>Attraction of add'l funding</td>
<td>Attracting fac/students</td>
<td>New innovative grad students</td>
<td></td>
</tr>
<tr>
<td>NSF Supplemental Awards</td>
<td>NSF operations guidance and feedback</td>
<td>Research proposals</td>
<td>Awareness of other NSF funding (for universities)</td>
<td>Change in Institutional (univ.) attitude twrd ind.</td>
<td>Enhanced university capacity to attract external res. $</td>
<td></td>
</tr>
<tr>
<td>NSF IUCRC Program Solicitations &amp; DCLs</td>
<td>Annual IUCRC Meeting</td>
<td>Research project results</td>
<td>Increased prestige from hosting centers</td>
<td>Faculty w/ diverse funding sources</td>
<td>Enhanced Faculty</td>
<td></td>
</tr>
<tr>
<td>University/Institutional</td>
<td>Review &amp; award of Supplemental funding proposal</td>
<td>Student posters</td>
<td>Org learning, development (diffusion of center model)</td>
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<td></td>
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</tr>
<tr>
<td>Leaders</td>
<td>University/Faculty/Students</td>
<td>Presentations at conferences (domestic, international)</td>
<td>Institutionalization of center operations and culture</td>
<td>Institutionalization of center operations and culture</td>
<td></td>
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</tr>
<tr>
<td>Valuable equip. &amp; facilities</td>
<td>Faculty</td>
<td>Pubs in high-quality science journals</td>
<td>Center research influences univ. courses/curriculum</td>
<td>Center research influences univ. courses/curriculum</td>
<td></td>
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</tr>
<tr>
<td>NSF</td>
<td>University/Faculty/Students</td>
<td>Center research reports for media release</td>
<td>Center growth</td>
<td>Center growth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Talent: faculty, researchers and students</td>
<td>University/Faculty/Students</td>
<td>Intellectual Property</td>
<td>Faculty scientists trained @ centers =&gt; positions of science leadership</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Research accomplishments</td>
<td>Faculty</td>
<td>Patent disclosures, patent apps, patents granted</td>
<td>Center growth</td>
<td>Faculty</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nature of research</td>
<td>Faculty</td>
<td>Student graduates</td>
<td>Shorten innovation cycle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More complex, &quot;team science&quot;</td>
<td>Faculty</td>
<td>Degrees awarded to</td>
<td>Patents in use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSF</td>
<td>University/Faculty/Students</td>
<td>Evaluartor</td>
<td>Technologies developed and deployed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced indirect support</td>
<td>University/Faculty/Students</td>
<td>Semi-annual meetings and social events</td>
<td>Commercialization, Univ. R&amp;D =&gt; Ind. R&amp;D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplemental support for admin and students</td>
<td>University/Faculty/Students</td>
<td>Evaluartor</td>
<td>Technologies meets social needs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University buy-in</td>
<td>University/Faculty/Students</td>
<td>Evaluartor</td>
<td>Technologies implemented and in use by consumers</td>
<td>University/Faculty/Students</td>
<td>New relationships btwn Univs and Ind.</td>
<td></td>
</tr>
<tr>
<td>Existing international</td>
<td>University/Faculty/Students</td>
<td>Evaluartor</td>
<td>NSF supported by universities</td>
<td>NSF supported by universities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSF</td>
<td>University/Faculty/Students</td>
<td>Evaluartor</td>
<td>Philanthropy increased from Ind. to Univ.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSF</td>
<td>University/Faculty/Students</td>
<td>Evaluartor</td>
<td>$ support for innovative res. ideas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSF</td>
<td>University/Faculty/Students</td>
<td>Evaluartor</td>
<td>Greater industry support of academic research</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSF</td>
<td>University/Faculty/Students</td>
<td>Evaluartor</td>
<td>University/Faculty/Students</td>
<td>New relationships btwn Univs and Ind.</td>
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<td>NSF supported by universities</td>
<td>NSF supported by universities</td>
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Solution

Show the value of hard work in I/UCRCs

The why and how of cooperative research

• Center Director Metrics: Awards & Funding Levels, Career Impacts, Quality of Research (Type, Pubs, Citations, Patents)
• Industry metrics: Cost avoidance, cost saving, follow on research, students hired, network effects
• NSF: demonstration that triple helix approach works (more jobs, better science, broader societal challenges addressed)

Why and how centers work: Which data? Who uses? What is feedback is most relevant to decisions?
Example: IMD Develops “IAB Engagement Metrics”

Sending a message via evaluation: these are the behaviors that help

**CANFSA IAB Engagement Metrics**
- Review of Student Resumes (booklet sent during winter, Y/N)
- Summer internships, offered/hosted (Y/N, #).
- Other internships (#)
- Jobs for qualified Center students (actual/likely number)
- Submit Research Proposals/RFPs (Y/N)
- Providing names and contacts for X companies as leads (Y/N and #)
- Willing to visit companies with Center management (Y/N)
- Willingness to support visit to your company by Center management (Y/N)
- Willingness to serve as IAB members to address these tasks, set timeframes (Y/N)
- Participate in between meeting calls and WebEx’s regarding Center (Y/N and #)
More Examples

- Social and Human Capital Impacts of the IUCRC Program on Faculty Directors (Denis Gray & Drew Rivers 2012)
- Graduate Student Social Capital, Social Networks (Lena Leonchuck 2015)
- Citation analysis and Bibliometrics (Lindsey)
Bibliometrics

- A methodology used to assess the impact of publications
- A category of metrics based on citations
- Emergent and rapidly developing – paradigm shift based on rapid expansion of web-based data
  - Professional social networking
  - Web analytics
- Data sources
  - ISI
  - Scopus
  - CiteSeer
  - Google Scholar
  - ResearchGate, Mendeley, PLoS, ImpactStory
### Traditional Bibliometrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Definition</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Citation counts</strong></td>
<td>number of citations to a particular article</td>
<td>Indication of scientific impact; tends to be a lagging indicator as citations take time</td>
</tr>
<tr>
<td><strong>Journal Impact Factors</strong></td>
<td>the average number of times articles from the journal published in the past two years have been cited</td>
<td>A more proximal indicator of scientific impact; uses the venue quality as a indicator of article quality</td>
</tr>
<tr>
<td><strong>Category Impact Factors</strong></td>
<td>the average JIF for journals in a given field</td>
<td>Can be used as a baseline for comparing the impact of particular publications relative to typical impact in a particular field of study</td>
</tr>
<tr>
<td><strong>Author h-index</strong></td>
<td>based on the set of the scientist's most cited papers and the number of citations that they have received in other publications</td>
<td>Can be used to evaluate the impact of a particular researcher; can create aggregate h-index for a research group</td>
</tr>
</tbody>
</table>

*ISI Journal citation Reports (accessed 2015)*
## CAPPS Example:

### Journal Impact Factors

<table>
<thead>
<tr>
<th>Title</th>
<th>IF</th>
<th>Category IF(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. of Microwave Powers &amp; Electromagnetic Energy</td>
<td>not in ISI</td>
<td>N/A</td>
</tr>
<tr>
<td>Intl Journal of Food Properties</td>
<td>0.615</td>
<td>0.911</td>
</tr>
<tr>
<td>Journal of Food Science</td>
<td>1.255</td>
<td>0.911</td>
</tr>
<tr>
<td>LWT - Food Science and Technology</td>
<td>1.589</td>
<td>0.911</td>
</tr>
<tr>
<td>Journal of Food Engineering</td>
<td>1.848</td>
<td>0.851(^2)</td>
</tr>
<tr>
<td>Journal of Food Protection</td>
<td>1.886</td>
<td>1.424(^2)</td>
</tr>
<tr>
<td>Pattern Recognition</td>
<td>2.019</td>
<td>0.902(^2)</td>
</tr>
<tr>
<td>Food Microbiology</td>
<td>2.039</td>
<td>1.713(^2)</td>
</tr>
<tr>
<td>Food research international</td>
<td>2.271</td>
<td>0.911</td>
</tr>
<tr>
<td>Applied &amp; Environmental Microbiology</td>
<td>4.004</td>
<td>1.534(^2)</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>1.95</strong></td>
<td><strong>0.969(^3)</strong></td>
</tr>
</tbody>
</table>

\(^1\) ISI Journal Categories: Comp Sci & AI; Food S&T; Microbiology; CE, Biotech & Applied Microbiology; EE

\(^2\) Journal listed in multiple categories, # reported is the average median IF

\(^3\) Average median IF across all categories in which journals are listed
Traditional Bibliometrics

• Pros:
  – Quantitative measure of research impact
  – Allows for more proximal evaluation
  – Objective, not based on self-report
  – Goes beyond pub counts – indication of pub quality

• Cons:
  – Field in transition: lots of overlapping, conflicting, and partial data sources; metrics reliability and validity limited by data base completeness
  – Not appropriate for all fields: those that don’t prioritize journal publications (i.e. computer science), emerging areas
  – Lack of consensus among evaluators as to appropriate bibliometrics for evaluating impact
Emerging Bibliometrics

• Co-authorship networks
  – Social network analysis based

• Web Analytics
  – Very immediate indicator of interest in a publication
  – Useful for evaluating non-traditional dissemination venues (magazine pubs, blogs, news coverage)
  – Useful for assessing social/public impact of centers
  – Many platforms offer their own metrics based on their own data sources
  – Hits, Views, Downloads, Likes, Comments, Follows
Patent Tracking

• We collect data on Center patents, but most centers work in the pre-competitive area, and do not pursue patents
• However, Industry may patent based on IUCRC findings
• Historically based
• Helps uncover the complex evolutionary path of innovations
• Potential to identify spillover effects
• Downstream and upstream analysis possible
Patent Tracking

• Using USPTO Data for downstream impact evaluation
  – Previous Art [OREF/keyword]

• www.google.com/patents
  – http://www.google.com/advanced_patent_search
CChIPS Example: Downstream Patent Tracking

• Search Term: Oref/arbogast
  – Patent No. 8,056,975: Travel seat restraint system (2011). Artsana USA, Inc.
  – Patent No. 8,864,166: Travel seat engaging system (2014). Artsana USA, Inc.

• Artsana was NOT a CChIPS member... Spillover impact
Patent Tracking

• Pros
  – Identifies indirect effects of research
  – Concrete metric for impact
  – goes beyond just economic impact

• Con
  – USPTO data are not standardized
  – These types of impact take a long time
  – Many IUCRC ideas are not patentable
Discussion

• These are just some of the possible evaluation metrics we could consider?
• What other metrics can we identify to help fill out the logic model?
• What other metrics can we identify to help demonstrate the impact of centers?
• What metrics are appropriate for centers with a social/public good mission?
Next Steps

**Inputs**
- NSF: *Funding - Prestige*
  - *Evaluation - Best practices and technical assistance - Program requirements - Organizational capital*
- University: *Human resources (faculty, researchers, students) - Equip. & facilities - Research accomplishments - Financial support (reduced indirect, support for admin and student) - Social capital (Existing collaborations, networks) - Organizational capital (policies, mission, culture)*
- Industry: *Financial support - Technical insight and direction - Research accomplishments - Specialized equipment and materials - Time - Human capital - Social capital*

**Activities**
- Lead & Manage Center: *Leadership - Implement center model (best practices) - Recruit members - Coordinate research agenda - Evaluate - Plan and select research*
- Conduct industrially relevant research: *Collaborate with other researchers (industry and university) - Teams conduct research - Manage projects to meet industry standards*
- Partnering / boundary spanning: *Link center-research industry - Interact with / among members - Share knowledge and ideas - Participate in center meetings*

**Outputs (First Yr)**
- Center Operations
- Research results: *Reports, publications, presentations - theses & dissertations - Intellectual property*
- Human capital: *Faculty - Students with skills relevant to industry - Industry members with deeper understanding of university resources, skills, talent - Research management skills (direction)*
- Social capital: *Increased trust among and between university and industry members*

**Short-term Outcomes (1-2 Yrs)**
- Faculty: *Increased scholarly productivity - Enhance academic reputation - Advances in knowledge - Skills in collaborative research - Consulting / contract opportunities - Ability to attract / support students - Understanding of industry needs and opportunities - Industry network*
- Students: *Increased opportunities for internships/employment - Research achievements - Industry network - Social capital*
- Industry: *Access to potential employees - Efficient R&D - Amplified R&D - Broader scientific network - Access to IP*

**Intermediate - Long-term Outcomes (3-10 Yrs)**
- Center / University: *Self-sustained partnership with industry - Increased ability to attract faculty, students, and external research support - Deeper and increased interactions with industry - Enhanced reputation - More entrepreneurial culture*
- Students (Alumni): *Enhanced career opportunities - New skills in bridging between university and industry contexts - Enhanced social capital*
- Industry: *More efficient research - Access to potential employees - Ability to capitalize on university research - New / improved products, processes, know-how and / or services - Broader scientific network (social capital)*

**Impacts**
- Enhanced research and innovation ecosystem: *Strengthened connections and feedback among parts of the system - Enhanced economic competitiveness - Expanded innovation capacity - Increased / enhanced scientific and technical human and social capital*

**Spillovers / Externals**
- Sector specific impacts of new products / processes - Broad social impact

**Key:**
- No research to date
- Significant progress but needs to be updated
- Sufficient current research
IAB Engagement Metrics (CANFSA)

- Review of Student Resumes (booklet sent during winter, Y/N)
- Summer internships, offered/hosted (Y/N, #).
- Other internships (#)
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