Project selection
A process analysis

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Abstract

Technology-oriented companies involved in rapidly changing markets are interested in the value of collaborative efforts aimed at the realization of shared benefits, while spreading the costs and risks across multiple partners. The experiences and insights of participants in such ventures can contribute to the understanding of how to build more productive alliances. This study examines the project evaluation processes employed by the most successful industry–university research centers sponsored by the National Science Foundation. The delivery of highly satisfying research programs, as indicated by the industrial representatives, is defined as being successful. This paper focuses on the process management issues involved in the formulation and evaluation of research proposals, structural advantages and liabilities associated with the process, as well as the conditions/contexts that favor their application. These processes are strategically significant because they define the organization’s research agenda, focus resource allocations by linking capabilities and commitments, and frame the performance assessment process.

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1. Introduction

As the duration of strategic windows [1] associated with technological innovations becomes shorter, the need for more rapid innovation with sensitivity to market timing has raised the pressure on firms to improve the evaluation, direction and control of the R&D function. Menke [2] suggests that “the decisions to initiate, continue, modify, and terminate R&D projects are the key to doing the right R&D.” He also states: “high quality assessments of the time and cost to completion, the probability of success, and the potential value of an R&D project provide the basis for high-quality R&D project decisions and strategic R&D management”. This study examines the Industry–University Cooperative Research Centers (IUCRC) program administered by the National Science Foundation.

For more than two decades, the IUCRC program has developed collaborative research programs that combine resources from industry, university and government partners to advance various technologies. This strategic partnership currently involves thousands of researchers and industry representatives in focused technology development activities at 57 different university-based research centers (see Appendix A).

In this collaborative context, productivity is broadly defined as the realization of diverse product and process benefits sought by the constituents involved. One of the key driving forces of the IUCRC is the center director (CD), whose prime responsibility is to develop and implement a productive technical research program. Similar to the head of the R&D function in a corporation, the CD is responsible for identifying and providing the resources to implement the research projects most likely to lead to the technological advances required by the center’s sponsors or “client” organizations. Central to this task is the translation of technical visions into proposals for research projects that can be presented to and assessed by the industry representatives selected by sponsor firms to constitute the Industrial Advisory Board (IAB).
In most of these alliances, the role of the IAB can be described as the “client” interface through which the needs of sponsor firms are communicated. NSF believes that technological innovations with high market value will be produced through the satisfaction of the commercial needs of these clients. This interactive translation process requires CDs to be highly sensitive to changing industry needs, perceptions of the center’s program and implications for related projects.

Souder and Mandakovic [5] summarize the evolution of project selection and evaluation models in response to these changing needs of collaborative organizations. They emphasize the abundance of evaluation methods and the neglect of process. Prior studies indicate that the traditional decision event models have seen only limited application to the R&D evaluation needs of single firms (cf., Refs. [4–7]). Steele [8] presents a broader industry-oriented overview of how R&D program management has changed over several decades. He concluded that the growing demands on R&D management have probably increased the need for coordinating the involvement of participants with increasingly divergent needs and backgrounds (i.e., process management) as opposed to the development of more sophisticated quantification methods for selecting projects.

The rigidity of traditional decision event models for project selection has limited their application in more complex environments such as collaborative research centers. Kanter [3] provides a good discussion of the organizational and interpersonal obstacles involved. Some project decisions are evolutionary in nature and require the coordination of functional subunits (e.g., R&D, marketing and production) at various levels in the managerial hierarchy [4]. Rubenstein [6] asserts that modeling R&D project selection is made even more difficult because behavioral realities are not well captured in existing R&D project selection models. Other issues in reducing project selection problems to simple numerical formulations include the fungibility of costs and benefits, risk assessment, an accounting for unsuccessful projects, and learning benefits and additions to the organization’s technology base or imbedded technological capabilities.

How can the project evaluation process be improved to meet the evolving needs of collaborative organizations? Prior studies have identified several key factors that should be considered as a basis for this process restructuring. Specifically, this paper discusses how project evaluation processes can be improved to meet the evolving needs of collaborating organizations by investigating the successful collaborations in the NSF database. It starts by considering the influences on successful matching of the project evaluation process with organizational contexts. It then documents the project evaluation processes of NSF’s successful collaborative research centers. This includes identifying the activities involved in these project evaluation processes as well as the sequences in which they occur. These activity sequences are then aggregated to form process models that managements can use for coping with specific organizational contexts. Finally, this paper shows how to use the process models identified as a maturing collaboration that evolves over time.

1.1. Factors influencing successful matches between process and context

1.1.1. Evolution of relationships

In settings involving multiple organizations, the critical need for flexibility in R&D evaluation is influenced by the evolution of the relationship among consortia members. Millson et al. [9] and Kanter [3] describe the process by which such relationships evolve over time. Different R&D evaluation criteria and processes are required to achieve success as consortia relationships evolve over time. Millson et al. describe the collaborative new product development processes of partners in early stages of their respective relationships vs. those in the later stages of such relationships. They suggest that, “during these initial stages, partners can agree on a well thought-out, documented plan that embraces each partner’s goals and methods for mutual new product development.” As trust builds in later stages of the relationship, greater flexibility may be tolerated and even desirable.

1.1.2. Evolution of market and technology

Beyond the evolution of the collaborative relationship, the evolving context outside of the R&D organization is an important consideration. This includes the pressures on the organization generated by evolving competitive technological capabilities, with the concomitant threat of technological substitution, and evolving market needs. It seems clear that changes in the rate of evolution in these critical areas will demand flexibility on the part of the R&D organization in the process of evaluating and selecting future projects as well as modifying current ones. Markets or technologies that are evolving more rapidly will put pressure on the members of the collaboration to produce outputs more quickly and, thereby encourage the adoption of project selection processes, which require less time to reach completion.

1.1.3. Nature of research

Collaborative research organizations often pursue a mixed research agenda that combines research projects of an applied nature (e.g., applications of technologies to a novel domain) with more basic research (e.g., fundamental development of the technology). Processes that depend on formal evaluation models are likely to favor projects of a more applied nature, especially when they have more immediate impact on consortia members. Basic research may be less attractive because of its less certain outcomes and longer-term impact, particularly when perspective sharing discussions are severely limited by time constraints. To the degree that a center’s evaluation process incorporates formal evaluation models, the resulting mix of projects is likely to favor applied research. To the degree the process
incorporates sharing of perspectives between academic researcher and industrial representative, the resulting mix of projects is likely to favor basic research. The mix of these different types of research, therefore, is likely to depend upon the nature of the project selection process adopted by the management of the respective R&D alliance that is the center.

1.1.4. Organization culture

A critical issue in the development and operation of an R&D consortium is achieving convergence on a vision and strategic intent [16]. According to Myers and Rosenbloom [10], a technology strategy begins with “a powerful research vision that is integrated with the corporate strategic intent.” Important to the process of illuminating these critical elements is the development of a shared organization culture or shared set of assumptions about the technological domain and how to most effectively identify research opportunities [11]. Kanter [3] alludes to this process when she states that firms seeking partners must seek out those with the “right chemistry.”

What cultural differences might exist and what do they portend for collaborative R&D ventures? Faulkner [12] identifies two approaches or “mindsets” regarding R&D project evaluation and selection: discounted cash flow (DCF) and “options thinking”. The DCF mindset (or culture) sees its fullest expression in most of the classical decision event models mentioned earlier. It is based on the assumption that uncertainty consumes value; hence, many managers focus upon the short term because long time horizons invite uncertainty. In contrast, managers involved in an “options thinking” culture believe that value is created by uncertainty, and therefore focus upon the long term. Hence, the evaluation of R&D programs occurs over a sequence of decisions (decision process) where a choice can be made to continue or terminate a project depending upon the outlook for the technology at each decision point, as opposed to a single point in time.

This “process-oriented” culture also recognizes the value of intangible benefits resulting from engaging in R&D projects, in addition to the ultimate commercial success of the product(s) that result. Faulkner contrasts R&D organizations in the US, which exemplify a DCF mindset or “decision event culture,” with Japanese R&D organizations, which exemplify an “options thinking” mindset or “process culture”. Similarly, Werner and Souder [13] contrast the US and German philosophies regarding R&D management and evaluation: US managers evaluate R&D over a short time horizon with a focus upon quantitative measures of output, while German managers are content to evaluate R&D efforts over a longer time horizon using inputs as measures of the value of R&D. The US philosophy is suggestive of the DCF mindset and the German philosophy is more similar to that of the Japanese or “options thinking” mindset. Clearly, these two cultures represent opposite extremes along a spectrum. No single collaborative R&D alliance is likely to represent either extreme, but instead a unique balance of both cultures.

As the number of partners in collaborative R&D alliances increases, the risk of culture clash also increases. As diversity grows in multimember settings, the processes involved in the selection of projects will require greater ability to bridge cultural differences. The goal of those crafting a decision process for a collaborative R&D effort is, therefore, to develop a process that not only responds to the external environment within which the collaborating organizations must operate, but also balances the need for quantification of benefits and interaction among member firms.

1.2. Issues

The growing importance of collaborative R&D organizations has increased concerns for identifying opportunities and resolving problems associated with process management. One critical subset of these issues focuses on how to improve the project selection process in collaborative settings that involve participants from multiple firms. These strategic partnering concerns include the following issues that are addressed by this research:

1. What are the appropriate process components (e.g., traditional project evaluation models vs. systemic process models) for facilitating convergence upon a shared vision and strategic intent?
2. What sequence of activities (e.g., process structure) has been most effective in reaching consensus regarding the projects in which the consortium is now engaged?
3. How can the project evaluation process be redesigned to improve flexibility and sustain commitments as the relationships among consortium members evolve?

2. Method

Successful alliances were identified by the delivery of highly satisfying research programs as indicated by the satisfaction ratings from their industrial memberships. Many of the alliances were successful in generating greater resource endowments, relative to the other centers. Qualitative data were collected from 17 highly successful IUC centers selected to represent the “best practices” in managing R&D alliances. A mix of telephone and personal interviews was conducted with the 17 CDs and their IAB leaders.

The sampling process was implemented in three stages: (1) the 57 IUCRC with data available in the 1993 Process Outcome Survey (POS) were classified into four categories based on endurance (fewer than 7 years vs. 7 years or more in operation) and endowment (less than US$700,000 vs. US$700,000 or more in operating budget); (2) centers representing each category generating relatively high sat-
satisfaction ratings among the IAB representatives from the POS were identified as targets for interviews; and (3) interviews were scheduled with directors from 17 of these centers. Interviews were scheduled to assure representation from each of the categories while focusing on centers with greater resource endowments since those centers with higher endowments had devoted more time and effort to developing their project evaluation procedures. Differences in performance between centers included in the data collection as compared to those that were not included are dramatic. Centers involved in the qualitative data collection have been more successful in attracting resources. On average, these centers have nearly triple the annual operating budgets (US$1.8 million vs. US$687,000) and feature a greater number of sponsor firms (16 vs. 13), supporting a higher number of researchers (23 vs. 15) compared to the centers that were not included in this research.

IAB representatives were interviewed from four of these high performance centers where the centers’ directors were supportive of in-depth interviews with members of their sponsor firms. Interviews ranged from 25 to 45 min with a total of 18 IAB representatives (further details can be found in a NSF report [14]).

3. Process components

In collaborative settings, the project selection process is composed of activity sequences that facilitate the convergence of participant perspectives to evaluate alternatives, establish priorities and make choices. An outside observer might view this process as the prevailing flow of decision-related communications among active participants. Active participants are more likely to view this interaction as the means of developing the shared mindset that is essential to effective collaboration. These shared mental models enable individuals to exchange insights and knowledge in group settings. Section 3.1 examines the variations in this process. Their insights provide a basis for fundamental process improvements.

3.1. Mapping activity sequences

Hempel and Daniel [14] identified the activity sequences (AS) used by IUCRC for project evaluation and clustered them into process components to prepare a consolidated view of the selection process. This paper uses the same activity sequences. Transcriptions of the in-depth interviews were translated into activity sequences and process maps to facilitate direct comparisons among the models adopted by collaborative organizations.

Table 1 summarizes the full set of procedures adopted for generating and evaluating proposals across the 17 centers selected for interviews. The frequency counts indicate the relative importance of each activity based on the number of times it was mentioned in the CD interviews. In general, there are four major components in the project evaluation process: (i) proposal generation, (ii) proposal refinement and modification, (iii) project and proposal presentations and (iv) project selection for funding. Based on the frequency counts, the two most common activities were the presentation of projects to the IAB (15), and faculty working with the IAB to refine the proposal (10). Diversity prevails for the other activities, with no single activity mentioned by more than 6 of 17 CDs.

It is important to note that not all of the elements shown in Table 1 are used when selecting a project. Different centers progress through the four main steps in different ways. Their different paths or activity sequences can be distinguished as alternative process models that vary in complexity, cost and value. Each model represents a distinctive activity sequence pattern, referred to hereafter as “process maps.” In some cases, the maps represent serial processes with sequential organizations of activities that could be identified as process stages or steps. In more typical cases, however, the processes described are not linear in nature because the activities associated with them are concurrent rather than sequential. This parallel processing of key activities has the advantage of collapsing the lead time required for project evaluation and selection in these centers. The maps presented here are comprised of process components as opposed to stages, purposefully avoiding the term “stage” because it implies serial activity. This distinction between the process as a whole (the architecture) and the core activities that enable the process to function effectively (the components) is a significant design consideration that enhances understanding of the process innovations involved (e.g., Ref. [15]). In the following discussion, references to process stage will be used to identify sets of activities that are typically grouped together, but not necessarily as serial clusters.

3.2. Alternative process models

The process descriptions provided by CDs were augmented through interviews with IAB leaders and consolidated into the eight process models summarized in Fig. 1. These process maps merit consideration as alternative models for implementing the project evaluation process. Each model represents a unique combination of influence-sharing protocols in the project selection process. Note that the letter associated with each model identifies a unique balance of power between academic researcher, and thereby basic research, and industry practitioner, and thereby research that is more applied in nature. Models identified with an “A” favor the academic researcher and basic research, while models identified with a “C” favor the industry practitioners and applied research. Models identified with a “B” represent a relatively even balance across both interests, representing true partnerships between industry and academic allies. Each model is described in greater detail below.
3.2.1. Model A1 — researcher-focused

This model gives the initiative and most of the decision making responsibilities to the faculty. This is distinct from the B and C models. The IAB has no direct role in the development and selection of projects aside from their financial contribution; their indirect influence is mainly in terms of reactive comments to the project report presented. The faculty decides on a project, gets money from the center to do the project, finds the appropriate researchers and implements the project. The IAB is kept informed of the project’s progress, but has no formal input into project selection. In the words of a director using this model: “We don’t say here are things we would like to do. We have a little section of our meeting that says ‘here are the new projects.’ It’s a subtle difference but we’re not really asking them for approval.”

3.2.2. Model A2 — advisory

In this model, the IAB meets to generate and discuss project ideas. Based on these ideas, the faculty develops preliminary proposals, which are then returned to the IAB for further refinement. Final proposals are then sent out to members for review before the meeting. At the meeting, proposals are formally presented, and the IAB makes the final decision by voting on each project. Unlike the previous model where members have no explicit vote, each member is entitled to vote, and their votes may have different weights. Usually the weight is determined by the amount of money or equivalent resources that the member company contributes to the center. According to a director for a center using this model: “...I use it almost in an advisory way. [The process]... gives us an opportunity... to meet with the chair of the IAB to review the input we did get from

Table 1
Overview of process activities

<table>
<thead>
<tr>
<th>Activity ID</th>
<th>Activity description</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Center faculty</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>IAB reps</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>RFP to all faculty</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Joint meetings with faculty and IAB</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>Developed by faculty to fit scope of center</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Developed by faculty to supplement existing research</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Focus groups</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>Developed with a specific company</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Initial, short proposal developed by faculty</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>Faculty develops final proposal</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>IAB fine-tunes proposals</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>RFP sent out for final proposals</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>Division director reviews proposal</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>Proposals fine-tuned by center coordinator</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>Proposals sent out to IAB reps for review</td>
<td>6</td>
</tr>
<tr>
<td>16</td>
<td>Faculty works with IAB members to refine proposals</td>
<td>10</td>
</tr>
<tr>
<td>17</td>
<td>Preliminary study done by center’s core faculty</td>
<td>4</td>
</tr>
<tr>
<td>18</td>
<td>Preliminary study by other faculty researchers</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>Technical committee fine-tunes proposals</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>IAB gives feedback on proposals</td>
<td>6</td>
</tr>
<tr>
<td>21</td>
<td>IAB may modify proposals</td>
<td>2</td>
</tr>
<tr>
<td>22</td>
<td>CD may modify proposals</td>
<td>1</td>
</tr>
<tr>
<td>23a</td>
<td>Mentoring program/ongoing proposal development</td>
<td>3</td>
</tr>
<tr>
<td>23b</td>
<td>Interactive poster session</td>
<td>7</td>
</tr>
<tr>
<td>24</td>
<td>All projects presented to IAB</td>
<td>15</td>
</tr>
<tr>
<td>25</td>
<td>All projects presented to CD</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>Director selects which projects will be presented to IAB</td>
<td>1</td>
</tr>
<tr>
<td>27</td>
<td>IAB ratifies research agenda</td>
<td>2</td>
</tr>
<tr>
<td>28</td>
<td>IAB votes on projects — each member has equal weight</td>
<td>6</td>
</tr>
<tr>
<td>29</td>
<td>IAB votes on projects — weighted voting</td>
<td>2</td>
</tr>
<tr>
<td>30</td>
<td>IAB votes on projects — consensus</td>
<td>4</td>
</tr>
<tr>
<td>31</td>
<td>IAB rank orders projects</td>
<td>5</td>
</tr>
<tr>
<td>32</td>
<td>IAB has several rounds of voting to determine final project list</td>
<td>1</td>
</tr>
<tr>
<td>33</td>
<td>Faculty makes final decision</td>
<td>1</td>
</tr>
<tr>
<td>34</td>
<td>Director makes final decision</td>
<td>5</td>
</tr>
</tbody>
</table>
Fig. 1. Alternative Process Models.

A1: Researcher focused -- director and faculty make decisions; IAB is informed.
- Project ideas come from center faculty - 1
- Projects presented to IAB - 24
- Faculty makes final decision - 33

Model A2: Advisory -- advisory board helps develop proposals.
- Project ideas come from IAB - 2
- Initia, short proposal developed by faculty - 9
- Faculty works with IAB to refine proposals - 16
- Proposals sent out to IAB for review - 15
- Projects presented to IAB - 24
- IAB votes on projects; each member has different weight - 29

Model B1: Industry partnership -- faculty works closely with industry throughout the entire process.
- Project ideas are developed with a specific company - 8
- Faculty works with IAB to refine proposals - 16
- Projects presented to IAB - 24
- IAB votes on projects by consensus - 30

Model B2: Focus groups -- process is structured according to core competencies.
- Center is divided into focus groups; ideas come from these group processes - 7
- Faculty works with IAB to refine proposals - 16
- IAB votes on projects; each member has equal weight - 28

Model B4: Customization -- Presentations tailored to individual interests of sponsors
- Ideas developed by faculty/student-mentor research teams - 4
- Ongoing project development via mentoring program - 23a
- Interactive, informal presentations - 23b
B3: Coordinator -- research coordinator assists faculty and industry throughout the

Project ideas come from faculty - 1

Initial, short proposal developed by faculty - 9

Proposals fine-tuned by coordinator - 14

Proposals sent out to IAB for review - 15

Projects presented to IAB - 24

IAB rank-orders projects - 31

C1: Strategic plan -- projects fit into center objective; IAB decides on project scope.

Project ideas developed through joint IAB-faculty meetings - 4

Project ideas fit into research agenda - 5

IAB ratifies research agenda - 27

Preliminary study done by faculty - 17

Projects presented to IAB - 24

IAB may modify projects - 21

IAB gives feedback on projects - 20

C2: RFP Solicitation -- proposals are solicited by industry and then filtered.

Project ideas come from RFP to all faculty - 3

Faculty works with IAB to refine proposals - 16

RFP sent out for final proposals - 12

Director decides which projects will be presented to IAB - 26

IAB has several rounds of voting to determine final project list - 32

Director makes final decision - 34

C3: Validation -- proposals are validated by a technical committee.

Project ideas developed in meetings with faculty and IAB - 4

Faculty develops final proposal - 10

Technical committee fine-tunes proposals - 19

Projects presented to IAB - 24

IAB votes on projects, by consensus - 30

The numbers in each box correspond to the Activity ID in Exhibit 1

Fig. 1 (continued).
Table 2
Benefits and limitations of alternative process models

<table>
<thead>
<tr>
<th>Model</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Research favored</th>
</tr>
</thead>
</table>
| A1 — Researcher-focused | • Time savings as faculty exercise more initiative  
• Attracts highly accomplished researchers who value discovery and publication  
• Opportunity for researchers to obtain reactions to ideas before commitments are made  
• Opportunity to gain insights into topical areas of interest to the IAB  
• Opportunity for IAB to comment on the relevance of the research, raising issues that may influence development of proposal ideas | • Potential for failure to align center research agenda with IAB needs  
• Can degenerate to reliance on reputations and past performance  
• Discussion focused on faculty ideas, discouraging other project ideas that the IAB may want  
• IAB may place unrealistic demands on center faculty  
• Weighted voting may allow a company to strongly influence some areas of the center’s research program by concentrating votes  
• Voting dominance may discourage participation among smaller firms and those committed to collaboration | Basic research |
| A2 — Advisory  | • Time savings as faculty exercise more initiative  
• Opportunity for researchers to obtain reactions to ideas before commitments are made  
• Opportunity to gain insights into topical areas of interest to the IAB  
• Opportunity for IAB to comment on the relevance of the research, raising issues that may influence development of proposal ideas | • Discussion focused on faculty ideas, discouraging other project ideas that the IAB may want  
• IAB may place unrealistic demands on center faculty  
• Weighted voting may allow a company to strongly influence some areas of the center’s research program by concentrating votes  
• Voting dominance may discourage participation among smaller firms and those committed to collaboration | Basic research |
| B1 — Industry partnership | • Some time savings as research ideas are developed cooperatively, no need for RFPs  
• Improved communication with IAB  
• Improved chance of fulfilling industry needs and expectations  
• Less opportunity for reaching an impasse in the IAB vote on funding | • Closed system, little opportunity for ideas from outside of the center — myopia  
• Loss of researchers operating at the periphery of supported topics | Neither |
| B2 — Focus groups | • Allows faculty and IAB members to concentrate on their area(s) of expertise  
• Focus group can designate a corporate champion to support the proposals at IAB meetings  
• Efficiencies of concurrent information processing, e.g., time savings | • Can fail to ensure adequate cross-functional understanding and cooperation within the center  
• Insights from detailed discussion in the groups may not be available to the broader membership  
• Program integration depends on the vision of a few leaders who maintain awareness of issues that span the groups  
• Effectiveness depends on the scope of the center’s research agenda | Neither |
| B3 — Coordinator | • Ease of responding to individual inquiries concerning projects | • Extra funding required  
• It may be difficult to find an effective coordinator  
• None | Neither |
| B4 — Customization | • Greater flexibility of focus  
• Greater privacy/security in the exchange of information  
• Better opportunities to customize project communications to specifically address interests of specific IAB member firms | | None |
For researchers, the personalized nature of interactions may reveal technical problems that are less likely to surface in open sessions. Opportunities to speak more freely allows IAB to influence projects early in their development when researchers are more open to input.

- Mentoring programs increase researcher performance
- Mentoring programs increase sponsor satisfaction with research outcomes
- Mentoring programs increase sponsor firm investments of resources

### C1 — Strategic plan

- Enhances collaboration
- Preliminary study ensures the feasibility of specific proposals
- Faculty has time to acquire resources and fine-tune the proposal

### C2 — RFP solicitation

- Encourages a greater number of faculty to participate in the center as researchers turn over with new RFPs
- IAB members will find it less time consuming since only a single meeting is required
- IAB members also find it less time consuming since less time required to maintain contacts with faculty before projects are approved

### C3 — Validation

- Early confirmation reduces the likelihood that the IAB will be dissatisfied at voting time
- IAB is assured that the research is relevant, valid and of high quality before approval
- Reduces the amount of time required for screening of individual projects by working through subgroups of participants

- An initial study may be unnecessary and costly if proposal is rejected
- While one company may decide to support a specific project rejected by the IAB, such behavior may threaten future collaboration among IAB members

- CDs find this approach to be more time-consuming due to the administrative steps involved

- Dependence on a small group to represent the interests of the entire IAB, with limited opportunity for detailed project review after validation
- Failure to agree upon and clearly communicate criteria for validation leads to miscommunication and conflicts of interest

- Applied research
industry and make some knowledgeable decision as to which ones we would approve for them to be heard at the summer meeting.”

3.2.3. Model B1 — industry partnership

In this model, the IAB members, faculty and center work together at all stages of the proposal development and project selection process. There is open communication between the parties throughout the process, including a question-and-answer period after the project presentations. The final projects are selected in IAB meetings by means of an open discussion with final decisions dependent on group consensus. In the words of a CD: “we have an industry advisory board that also consists of faculty. And this board actually develops in-unison proposals for projects that would then be the next year’s projects.”

3.2.4. Model B2 — focus groups

In this model, the major research interests of each center are divided into separate clusters. Interested IAB members are encouraged to form focus groups during the regular IAB meetings. The discussion in each focus group is concentrated on a particular set of problems and applications (e.g., technology areas/project areas, industry problem areas, etc.). Within the focus groups, certain faculty and IAB members team up to refine specific proposals for further consideration. However, at the IAB meeting, all of the faculty researchers and IAB members review all of the project proposals. Each proposal is voted on during the meeting by the IAB members; each member’s vote carries the same weight in the process as all other members’ votes. To quote a CD: “we have focus groups—what we call industry focus groups. All of the petroleum companies sit down in a room together. All the XYZs sit down together, food groups together, etc.”

3.2.5. Model B3 — coordinator

This model features a special catalytic component—the research coordinator role. Basically, the responsibility of the research coordinator is to “keep on top of trends” and be the liaison with the IAB. S/he must make sure that proposals address the needs of the IAB, which in turn allows the CD to spend more time on other issues such as procuring additional grant funding or recruiting IAB members. In this model, faculty members provide project ideas in brief proposals (e.g., a one-page concept or problem statement). The research coordinator then fine-tunes these proposals and sends them out to IAB members for review. According to one director using this model: “having a person who’s primarily interested in quality aspects of center operation has been a real important success factor for us.”

3.2.6. Model B4 — customization

In this model, project ideas are presented by the faculty researchers as components of preliminary proposals, partial prototypes (e.g., software demonstration), or conceptual outlines. Some centers focus these efforts at scheduled meeting events, such as poster sessions with emphasis on display boards and small group communications. Other centers use mentoring programs to develop ongoing relationships between sponsor firms and specific research teams that provide similar opportunities for customized dialogues. Research ideas are presented in informal settings to representatives who might be interested in the potential project or technology area. Such settings might be modeled after a trade show or convention where different inventors/vendors occupying different booths or stations present their products. In this case, however, the “inventor/vendors” are faculty research associate teams, and the product is a set of project ideas. These sessions are often held during breaks in the formal IAB meeting, or scheduled as transitional events toward the end of the formal meeting. Representatives are then free to visit any booth, station, room or session that is of interest and observe the presentation or demonstrations. According to advocates of this model: “We rely on poster sessions pretty heavily to bounce ideas off the IAB. During a poster session you can have anything from a reasonably polished presentation to an off-the-wall series of ideas.”

3.2.7. Model C1 — strategic plan

In this model, project ideas are developed in unison with sponsor companies to fit into the scope, focus and research agenda of the center. By defining an explicit research agenda, the center guides faculty and IAB research efforts into priority areas. In one center using this model, the IAB votes on the research agenda only, approving it for the year. The faculty members then conduct preliminary studies and present the findings to the IAB. At that time, the IAB may modify the project and provide feedback. According to one CD, “Every time we meet, we discuss the emerging research agenda, and we discuss particulars of the present research development. It’s also done formally in writing… the second part is introducing the new agenda. But the new agenda is not suddenly put in front of everybody, love it or leave it, in May or June. It has gone through a whole year iteration.”

3.2.8. Model C2 — RFP solicitation

In this model, project ideas come out of requests for proposals that are sent to all faculty members in the participating universities. Once the preliminary proposals are received, the IAB meets to determine a final list of project ideas. RFPs for the final list of projects are then sent out to faculty who have participated in the center’s research program and to other faculty who may be interested in the topic. Proposals come back to the CD, who determines which ones will be presented by their faculty sponsors at the IAB meeting. After the presentations, the IAB votes over several rounds until they come up with a satisfactory final project list. The CD then decides which projects on the list
will be funded, taking into account the IAB’s comments. In the words of one director whose center uses this model: “We scope out what will be the needs, the interest areas and our center’s focus. We commit that to a list of priority items and we create a request for proposal against that kind of needs list.”

3.2.9. Model C3 — validation

In this model, initial project ideas are generated jointly through discussions between the faculty and IAB members. Based on these discussions, the faculty develops final proposals. A technical committee, essentially a subset of the IAB, reviews and fine-tunes the proposals. The project proposals are then presented to the IAB, who makes the final decision on each project. In the words of one director: “... we discuss these in the TAC (technical advisory committee) meeting and make recommendations concerning which projects ought to be phased out and which ones should be continued.”

In general, the researcher-dominant models, Researcher-Focused (A1) and Advisory (A2) models, featured increased time savings as faculty exercised the initiative for project development and enjoyed the realization of valuable insights via the feedback from the industry representatives. The downside of these models is the potential failure to encourage industry involvement, leading to lack of alignment in the program with industry needs.

The models featuring an industry dominance (C1, C2 and C3) benefit from early involvement by industry representatives, helping to assure that research proposals are relevant and of a high quality. This also helps to reduce time requirements. However, these models can be fraught with challenges from lack of agreement on and communication of criteria for identifying successful project proposals, which can lead to conflicts of interest among IAB members while discouraging researchers.

The models based on a more equal power sharing between researchers and industry representatives (B1, B2, B3 and B4) benefit from increased collaboration. This is manifest in the enhanced communications and cooperative development of research ideas and proposals, which results in increased time savings. Depending on how the collaboration is structured, however, some of these models may create barriers to sharing of insights among the broader center membership and base of researchers.

The specific advantages and limitations of each of the models discussed above are presented in Table 2 below.

4. Conclusions and implications

Industry has recognized that the available resources within a single firm are often too limited to support major, capital-intensive R&D projects [3]. In rapidly changing markets, technology-oriented companies have been particularly attracted to the value of collaborative efforts aimed at the realization of shared benefits, while spreading the costs and risks across multiple partners. The shift toward collaborative R&D is creating needs for new perspectives on innovation management.

From an industry perspective, membership in a center requires significant commitments of time and money. The decision to join a center involves the purchase of a stream of benefits that are expected to result from the firm’s participation in the center’s research activities. These include both tangible benefits (e.g., relatively early access to key technological innovations) and intangible benefits (e.g., enhanced knowledge about key technological innovations). Some benefits are difficult to measure directly and others may not be recognized or perceived as important by some members. These undervalued outcomes include benefits that may not be clear or apparent (e.g., access to a pool of talented future employees) until the member gains experience through participating in the center’s research program — hence the importance of studying the evolution of relationships when the experiences impact future commitment.

Our research indicates that industry views of center performance are influenced by an evolving set of expected and perceived benefits that shape value realization. Clearly, both value and performance are multifaceted concepts. It is difficult to measure the formation of value in university-industry alliances because of the diversity of perspectives across participants. Multiprogram systems pose special challenges to the assessment process because of this inherent complexity. The need for restructuring research and assessment processes was discussed by industry and government representatives at a workshop in 1995 [17]. The industry perspectives were presented by senior corporate research managers from four leading R&D organizations: IBM, AT&T, Ford and Xerox.

The NSF Office of Policy Support presented its perspectives on research restructuring and highlighted several assessment issues with significant implications for process management.

How should value be judged? From industry perspectives, “relevance is the key to value.” If performance indicators are supposed to indicate value, how is relevance to be judged in the context of changing industry representatives? Responsiveness is limited by the consistency of perspectives — the meaning of performance changes as new sets of managers bring new visions to their interpretation of program relevance and value.

Who are the customers? “You cannot tell whether research is working if you do not know who it is working for — you must interact with those people and get their judgments about it.” For example, to what extent should research be grounded in real world problems and connected to business judgments of relevance?

What is the appropriate time frame for evaluating performance? “The Government Performance and Results Act distinguishes between outputs and outcomes. Outputs are
the activities that go on under a program. These are the immediate, tangible things that you can see being produced as a result of program activities. Outcomes are things that happen over much longer periods of time. Most of the payoffs from NSF programs are in the outcomes category. The results that we will be able to track easily and count, if they are even worth counting, will largely be outputs.”

What are the appropriate measures of performance?
“Most agencies are going to report outputs in their performance indicators on an annual basis. They are going to learn about outcomes in other ways. For instance, at NSF, we can learn about outcomes through program evaluation, rather than through annual performance indicators. By program evaluation, I mean a much more in-depth look, a process that can be much more sophisticated, that takes all kinds of elements into account other than just numerical indicators, and that looks at what the programs are actually producing.”

The Government Performance and Results Act of 1993 called for a vigorous implementation of performance assessment systems across federal agencies by 1999. This legislation significantly impacts the evaluation of R&D programs involving industry, university and government collaboration. This study presents some insights into the strategic management perspectives required for improving the process components of this performance monitoring system. Some of the most impressive comments made by the CDs and IAB leaders interviewed highlight their mutual commitment to balancing concerns for flexibility and focus. Their comments and experience indicate that shared mental models can be effectively reconfigured through explicit strategic plans that link project objectives to integrated streams of deliverables.

The process models described here are derived from successful interorganizational collaborations as represented by the IUCRC system. They present useful means of addressing the issues of process management for other types of alliances among firms. They also represent means of reconciling competing perspectives within a single company, such as those arising in the development of novel technologies and substitute products. Process restructuring can help to overcome and synthesize conflicting views in the R&D and marketing interfaces (e.g., technology push vs. market pull), and thereby enhance the cross-functional teaming required for development of innovative products. These process models provide a means of addressing the concerns that arise in such situations by helping balance the impact of one group against another in the selection and implementation of projects.

4.1. Implications for managing collaborative R&D

Given the complexity represented by the nine process models identified in Exhibits 2 and 3, the following question arises: Which alternative(s) should one consider first? Is there some reduced set of models that might simplify the choice? Then the selection of an appropriate model for application in a given context can be examined.

As illustrated in this study, there is significant diversity in the process models employed by successful center managers in the field. This variety can be overwhelming if all of the options are considered in choosing a project evaluation model. Fig. 2 presents a participant-oriented spectrum consisting of five basic models, based on the original nine observed in the field. These five models are distinguished by the extent of industry–faculty interaction and the research philosophy of the center. At the midpoint of this spectrum, the commitment to joint efforts is pervasive as an operating philosophy. At the extremes, faculty or industry initiatives dominate the process. In one extreme, faculty initiatives define the scope of the research agenda and focus the process with anticipation that industry reactions and feedback should be considered in the final selection decisions. In the other extreme, industry initiatives define the scope and focus the process with anticipation that these criteria will be used to solicit proposals. The two mixed models represent evolutionary stages in the mutual commitments to champion collaborative efforts.

The relationships described here suggest that as perspectives, values and needs of the center’s population of sponsor firms and their representatives evolve, the selection of an appropriate management model for a new or existing collaboration should be considered as an adaptive strategy. The recommended approach to choosing an appropriate model for an existing center begins with the identification of the model that best coincides with the center’s existing process and operating philosophy. This assessment of the center’s prevailing practice should then be reconciled with its objectives, growth strategy and institutional constraints.

As summarized in Fig. 3, the project evaluation processes in more successful and mature centers are likely to evolve toward proactive collaboration. IAB members and academic researchers seem likely to gradually converge on process models that encourage initiatives from all participants. Center performance and program value are enhanced by a more universal commitment to collaborative efforts toward mutually valued outcomes. For example, in centers featuring an academic orientation, as the perspectives, values and needs of the sponsor firms change with the inevitable increases in representative knowledge of the center’s focal technology, this goal is achieved by progression from a Faculty Initiative model (M1) through a Core Competence model (M2) to achieve comfort with and adoption of the Joint Effort model (M3). Similarly, as a center based on an Industry Orientation matures with the concomitant changes in the perspectives and values on the part of the academic participants, it would be logical to progress from an Industry Initiative model (M5) to a Goal Agreement model (M4) and ultimately to the Joint Effort model (M3).

While a new center will have no existing process from which to evolve toward a more evenly collaborative process
Fig. 2. Combined Selection Models.
model, its managers will have an operating philosophy, and its prospective IAB members will join the center with a set of perspectives, values and needs regarding the focal technology. It will be important for the managers of the start-up centers to measure them and build an initial project evaluation process that is well suited to the emerging model such as the Joint Efforts model (M3). Instead, given a population of sponsor firms that requires new knowledge to fully appreciate the potential value of the focal technology, it may be more appropriate for the center’s director to adopt a researcher-dominant model such as the Faculty Initiative model (M1) and deliberately evolve the center’s process model toward the Joint Effort Model (M3), adopting the Core Competence model (M2) as an intermediate step.

Similarly, the director for a budding center, which features a population of prospective sponsor firms that possess investigative needs regarding the focal technology of the center that are not well understood by the faculty researchers, may require an initial project selection process model that favors the sponsor firms such as the Industry Initiative model (M5). As the faculty researchers and industry representatives achieve a more common vision of the potential of the focal technology, the center’s director may choose to evolve the project evaluation process toward the Joint Effort model (M3), adopting the Goal Agreement model (M4) as the basis for an interim model in that evolution.

The project evaluation processes described in the qualitative data for each of the centers included in this research were used to identify the Combined Selection model (see Fig. 3 above) represented by each of the included centers (see Table 3 below). Table 3 provides evidence to suggest that there is value in considering the migration from the extremes of researcher-focused or industry-focused process model toward a more collaborative model since the more collaborative models have been more successful. At an

<table>
<thead>
<tr>
<th>Center performance by process model</th>
<th>Not included in the qualitative data (34)</th>
<th>IUCRC centers included in qualitative data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of IUCRC centers</td>
<td>6.21</td>
<td>4.67</td>
</tr>
<tr>
<td>Mean years in operation</td>
<td>686,557.76</td>
<td>1,413,280.00</td>
</tr>
<tr>
<td>Mean annual operating budget (US$)</td>
<td>12.53</td>
<td>19.00</td>
</tr>
<tr>
<td>Mean number of researchers</td>
<td>15.47</td>
<td>15.67</td>
</tr>
</tbody>
</table>

Number of IUCRC representing individual models within the Industry/Researcher Partnership: (M2) Core Competence = 1, (M3) Joint Effort = 4, (M4) Goal Agreement = 3.
average US$2.3 million annually among the centers identified with a more collaborative process model compared to US$1.4 and US$1.3 million, respectively, for centers featuring researcher-oriented and industry-oriented process models, centers identified with a more collaborative model have generated higher annual operating budgets, i.e., higher endowments. While researcher-oriented centers feature a comparable number of sponsor firms compared to those centers featuring a more collaborative process model, the more collaborative centers have endured, on average, more than 2 1/2 years longer than the researcher-oriented centers and almost 1 1/2 years longer than the industry-oriented centers. The more collaborative centers also support more researchers than centers based on either of the extreme process models.

4.2. Important issues for future research

While the current research examines the processes involved in creating satisfying collaborative R&D programs, several important questions remain about the importance of process vs. outcomes for creating durable alliances. Clearly, creating a process for generating and sustaining a satisfying research program is important, as is the delivery of important research outcomes. The service literature distinguishes between failures involving process and outcomes, but does not provide any information regarding service customers’ differential reactions to these failures. Smith et al. [18] suggest that service customers will react differently to these different types of failures because they represent different categories of loss. Similarly, Leisen and Hyman [19] show a linkage among perceptions of process quality, trust and commitment in service relationships. A critical question, then, is determining how important satisfaction with the process vs. satisfaction with the research outcomes is in building and maintaining collaborative R&D alliances. Can the delivery of valued outcomes offset a less-than-ideal process for generating those outcomes? Conversely, can a highly satisfactory process offset delayed delivery of outcomes or delivery of less-valued research outcomes?

While the relationship marketing literature has considered the evolution of alliance and marketing relationships [3,20], it has not yet considered the differential importance of process quality vs. the delivery of outcomes over the evolution of these relationships. It seems possible that the importance of satisfaction with process varies at different points in the evolution of these relationships. When might satisfaction with the process be most important to alliance durability — early in the development of the alliance or later? Might there be times in the alliance when satisfaction with the process of operating the alliance is more important to the durability of the alliance than satisfaction with the research outcomes? When might that be — early in the development of the alliance or later?

Other researchers [21,22] have identified trust as important to the development of enduring marketing relationships. In fact, Garbarino and Johnson [21] suggest that trust may be more important than satisfaction in building enduring marketing relationships. How important is trust compared to satisfaction with process and outcomes in these strategic alliances? These researchers have suggested that the maintenance of trust is important throughout the life of a partnership such as those described here [21,22], while other researchers have suggested that trust is more important in the early development of such alliances [23,24]. Is trust more or less important to the endurance of the alliance at different times during these partnerships, or not? When is trust more important to the endurance of such an alliance — early in its development or later? The above are important questions that need to be resolved to provide guidance for building and maintaining enduring collaborative R&D partnerships.

Acknowledgements

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Appendix A. Sample composition

NSF’s IUCRC (as of 1994)

Institution
University of California, Berkeley
Carnegie-Mellon University
Georgia Institute of Technology
Georgia Institute of Technology/University of Arizona
University of Iowa

University of Michigan
New Jersey Institute of Technology
New Mexico Institute of Mining and Technology

Center
Center for Sensors and Actuators
Center for Building Performance and Diagnostics
Center for Material Handling
Center for Information Management and Research
Center for Simulation and Design of Optimization of Mechanical Systems
Center for Dimensional Measurement and Control
Center for Emission Reduction Research
Center for Energetic Materials
References


Harold Daniel is Assistant Professor of Marketing at the University of Maine. Having recently earned the PhD from the University of Connecticut, his research and teaching interests stem from the practical experiences in product development gained prior to starting his doctoral studies.

Don Hempel was Professor of Marketing (emeritus) at the School of Business Administration, University of Connecticut, where he served as Director of the Marketing Innovations Program at the Advanced Technology Center in Precision Manufacturing, as the NSF Evaluator for the center, as the Chair of the National Evaluation Research Committee for the Industry University Cooperative Research Centers program and the program evaluation team for the Academy, an NSF-sponsored regional educational coalition. His sudden passing in January 1998 left many who were grateful for his contribution to their lives, including the remaining authors of this paper.

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