# Best Practices for Industry-University Research Collaborations

by

**Julio Alberto Pertuzé Salas**

**Bachelor in Engineering,**
**Industrial Civil Engineer,**
**Pontificia Universidad Católica de Chile, 2005**

Submitted to the Engineering Systems Division
in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Technology and Policy

at the

Massachusetts Institute of Technology

June 2009



Signature of Author……………………………………………………………………………………………..
Technology and Policy Program, Engineering Systems Division
May 8, 2009

Certified by……………………………………………………………………………………………………...
Edward M. Greitzer
Professor of Aeronautics and Astronautics
Thesis Supervisor

Certified by……………………………………………………………………………………………………...
William A. Lucas
Director of Research, Gordon Engineering Leadership
Thesis Supervisor

Accepted by……………………………………………………………………………………………………
Dava J. Newman
Professor of Aeronautics and Astronautics and Engineering Systems
Director, Technology and Policy Program

**Best Practices for Industry-University Research Collaborations**

by

**Julio Alberto Pertuzé Salas**

Submitted to the Engineering Systems Division on May 8, 2009
in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Technology and Policy


## Abstract

This thesis reports a study of industry-university collaborations aimed at the development of best practices to enhance the impact of such collaborations on company competitiveness. The data sample involves twenty-five research-intensive multinational companies which engage in collaborative research on a regular basis. Over 100 different collaboration projects are analyzed through interviews with the responsible project managers and with senior technology officers. The interviewees provided both quantitative and qualitative information about the success and lack of success of the collaborations. Based on these data, seven best practices for managing collaborations have been defined which, when taken together, significantly contribute to the long-term success of the collaboration. These practices are: 1) select collaboration projects that complement company R&D; 2) select university researchers who understand specific industry goals and practices; 3) select project managers with strong boundary spanning capabilities; 4) promote longer collaboration timeframes; 5) provide appropriate internal support for project management; 6) conduct regular meetings at the company between university and industry researchers; and 7) build awareness of the university project inside the company.


Thesis Co-Supervisor: Edward M. Greitzer
H.N. Slater Professor of Aeronautics and Astronautics

Thesis Co-Supervisor: William A. Lucas
Director of Research - Gordon Engineering Leadership Program

# Contents

# Tables

# Figures

# 1. Introduction

## 1.1. The Open-Innovation Context

The rapid growth of scientific knowledge imposes new challenges for companies which need to maintain their research and development (R&D) capacity and keep track of current advances. As a result, companies are starting to outsource R&D, moving towards external sources of innovation, such as start-up companies, universities and other outside research organizations. This trend, referred to as open-innovation, emphasizes the importance of universities as a valuable source of innovation and new ideas (Chesbrough, 2003).

Open-innovation describes a paradigm shift on how companies are exploring and exploiting innovation. The former paradigm of closed-innovation considered that companies, in order to be successful, should retain the control of the whole innovation process. Companies expected to create their own ideas, develop them, manufacture them, and sell them all within the company's boundaries. The underlying logic was simple: if companies increased their internal R&D investment, they would produce new technological breakthroughs that would enable them to deliver new products and services first into the market. The new products and services would increase the company's revenues, which would leave more resources available to support further R&D expenditures, thus creating a virtuous circle to maintain leadership in their industries.

While this model served leading technology firms well for decades, certain eroding factors started to break this virtuous cycle. The most important ones were an increase in the number and mobility of highly skilled workers, and the emergence of venture capitalists who became experts in transforming new technologies into successful companies (Chesbrough, 2003). When the skilled workers left their companies, they took their experience, practices, knowledge, and ideas with them. In addition, they had the opportunity of exploiting their ideas by creating a company of their own. Venture capitalists served as a catalyst for transforming the ideas of scientists and engineers into such new companies. As these start-up companies grew, the increased competition further eroded the closed-innovation cycle since incumbent companies had fewer resources for further R&D investments.

As the closed-innovation paradigm became unsustainable, companies understood that they had to use both external and internal sources of innovation, and their mindset shifted to actively hunting for ideas and talent on a global basis. Adopting the perspective that the next breakthrough technology can emerge inside or outside their R&D lab, they changed from an inward-looking culture to an outward-looking approach that takes advantage of others' R&D results. If another company or university develops a technology that supports the company's business, they can buy a license or acquire the company through a merger or acquisition. Likewise, internal discoveries can also reach the market through external channels via intellectual property (IP) licensing or in a corporate spin-off.

### 1.2. Trends in Industry Funded University Research

Open-innovation highlights the importance of university-based research for industrial innovation. Some authors have determined that the university's contribution to industrial innovation is not only at the basic research end of the innovation pipeline, but also at the development end of industrial R&D. Start-ups and large firms from the drug, glass, metal, computer, semiconductor and medical equipment industries consider university research critically important for their own R&D capabilities (Cohen et al., 2002). As a result, industrial support of university R&D has risen in the United States since the 1970s (see Figure 1). Industrial support currently accounts for 5% of total academic R&D expenditures (National Science Board, 2008).

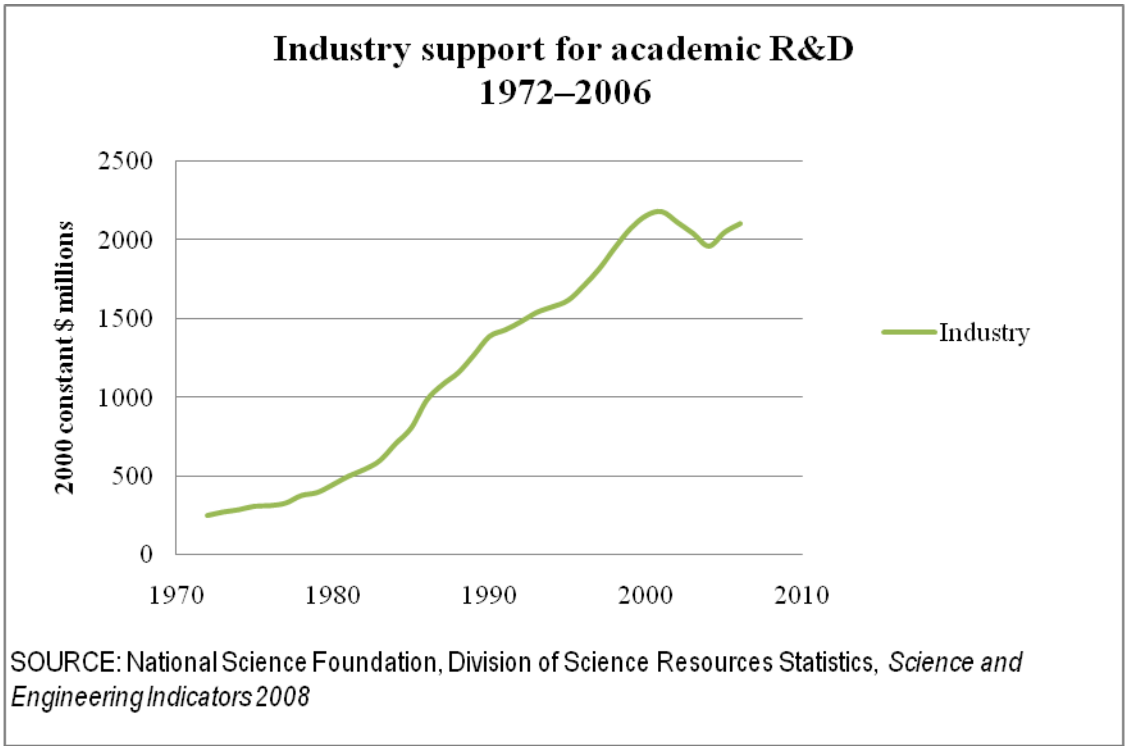


**Figure 1: Evolution of industrial support of academic R&D**

In the United States, this growth has been supported by more than eight pieces of legislation enacted to promote industry-university technology transfer (Bozeman, 2000). Of particular relevance was the Bayh-Dole Act (1980) which granted universities the control of all intellectual property (IP) resulting from federally-funded research. Universities have exploited this new revenue source through patents and licensing agreements, which has led to the creation of technology transfer offices in support of these collaboration efforts (Siegel et al., 2003).

These new dynamics have changed the role of universities in that they are expected to contribute not only with teaching and research, but increasingly with a third mission of technology transfer for economic development (UN Millennium Project, 2005). However, university-based research does not automatically evolve into business innovation. A major challenge lies in the ability of industry to take advantage of university research (Lambert, 2003). This problem was crystallized by the Lambert Report, a policy paper in the UK, which suggested that the lack of productive use of university research by UK companies was, to a significant extent, a result of company practices concerning the management of this research. The report further recommended the development of a set of "best practices" to guide future industry-university collaborations. We take this recommendation as our departing point.

## 2. Research Objectives

The goal of this research is to: *Identify, in a manner that can be acted upon, the attributes necessary for sustainable, productive, industry-university collaboration for industrial organizations, including the underlying rationales for collaboration and the metrics involved in project selection, management, and payoff—in essence, determine the best practices for such collaborations.*

The principal question addressed is why some research collaborations, despite producing interesting *outcomes* such as a published paper or a computer program, do not produce an *impact* on the company's productivity or competitiveness.

### 2.1. Thesis Structure

This thesis is divided into eleven chapters. Chapter 1 presents background information on industry-university collaborations. Chapter 2 describes the research objectives and the thesis contributions. Chapter 3 describes the research methodology. Chapter 4 presents a description of the collaboration projects surveyed. Chapter 5 describes the project's success metrics that are the stepping-stone for contrasting and validating the best practices. Chapter 6 describes an industry-university collaboration model. Chapter 7 presents three research propositions and the literature that supports them. Chapter 8 presents a statistical analysis that validated the three propositions. Chapter 9 presents additional research findings. Chapter 10 presents a summary of major findings. Chapter 11 (one page) then distills these findings into seven best practices project managers can follow for success in industry-university collaboration.

## 2.2. Personal Contributions to the Study

This thesis is part of a study to determine best practices for industry-university research collaborations. In the initial phase of the study (2005-2007), a team gathered information on 74 industry-university collaboration projects, at 16 different companies. The findings were discussed in the M.S. thesis of E. S. Calder. The present thesis reports a second phase of the study, aimed at broadening the understanding of the management practices that govern industry-university collaborations.

This thesis expands on the work performed by Calder. That work involved elaboration of the research survey and definition of the framework, methodology, and dataset this thesis utilized as its departing point.

My contributions were as follows:

1) Increase of the dataset to 106 projects and 25 companies, enabling new and different analysis of the management activities reported in the first phase of the project.
2) Expansion of the theoretical background related to the knowledge creation and technology management literature. From this expanded literature review, I developed three research hypotheses which were tested in this thesis.
3) Creation of an enhanced depiction of the collaboration process based on the new theoretical background and richer dataset.
4) Definition of a group of seven best practices based on the statistical analysis of the data that were shown to have positive effect on the success of the collaboration.

## 3. Methodology Description

Early in this project, a survey instrument was developed consisting of different practices connected with industry-university collaboration. The survey instrument also contained several questions aimed at determining how the industrial setting affected the collaboration process.

Through iterations with several companies, a refined survey instrument was then formulated. This survey allowed the collection of quantitative data which enabled a statistical analysis of the practices described by the companies.

Companies were asked to provide time to conduct approximately five hour-long interviews with project managers (the task owners) of different university projects as well as with senior managers who were the overall gatekeepers of the university collaboration. These senior managers provided an independent evaluation of the project's impact on the company.

Most of the interviews were face-to-face and conducted through a one-day visit to the company. Through the structured interviews, we also obtained qualitative data which provided examples on how these practices were set to work.

Project managers were asked to provide examples of both successful projects and those that failed to meet expectations. Further, we requested project managers to reflect on projects that had already finished so they could evaluate the outcomes and the impacts those projects had on the company.

## 4. Unit of Analysis for the Study

A useful way to classify industry-university joint collaborations is according to the degree to which they involve personal-face-to-face contact between researchers (Schartinger et al., 2002). There are "low contact" collaborations such as open science publications and patent licensing; and "high contact" collaborations, which includes a spectrum from direct support of individual researchers by companies to funding of large laboratories through industry consortia (Perkmann and Walsh, 2007).

This thesis will focus on "high-contact" research collaborations, and more specifically on industry-funded research ventures which involve individuals, or groups of, university researchers. Some studies suggest this type of collaboration is the most practiced form of industry-university engagement, accounting for 65% of all interactions (Lee, 2000).

While we acknowledge that managing research contracts and intellectual property is an important—and stressful—part of the collaboration, it is important to emphasize this study focuses on the management practices that start *after* the research contracts have been signed.

### 4.1. Characteristics of the Data Sample

This study used survey data from 106 different research projects, including interviews with the responsible project managers and senior technology officers, both of whom provided both quantitative and qualitative evidence on best practices for joint collaborations.

The projects were drawn from 25 research-intensive multinational companies which engage in collaborative research on a regular basis. Companies were invited to participate in the study based on our information about whether they had experience in collaborating with universities. We have consciously targeted successful companies since they have practices that can illuminate how to manage research collaborations. Therefore, this is not a random sample, and as a consequence there may be other sources of selection bias that might influence the study's conclusions. The distribution of the participating projects grouped by industries is shown in Figure 2.

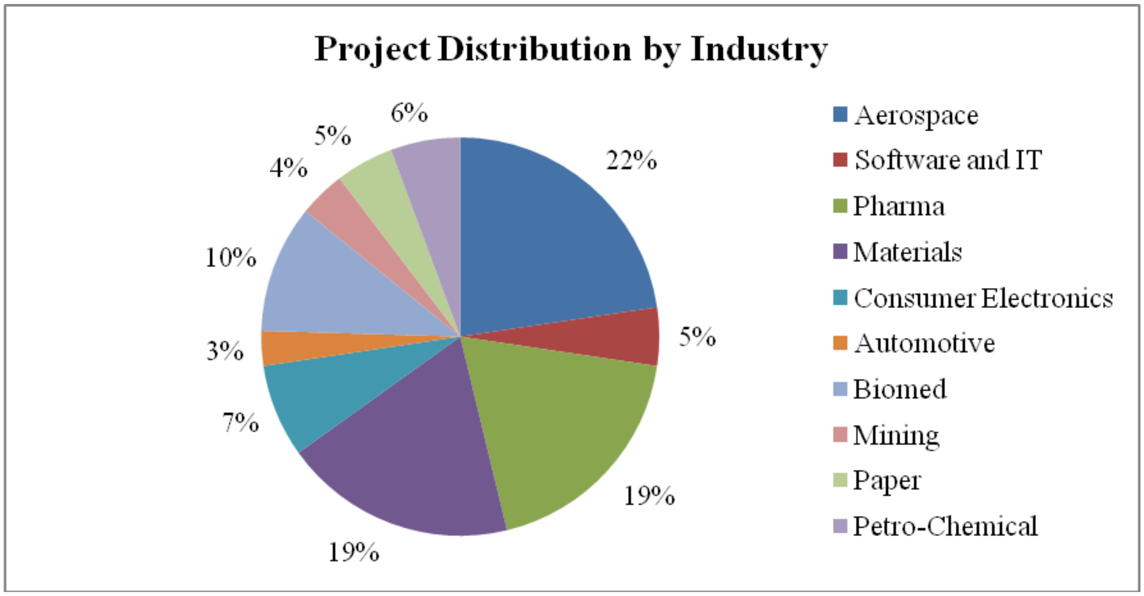


**Figure 2: Project distribution by Industry**

According to the senior technology officers, 93% of the companies had a central resource/office in charge of coordinating industry-university collaborations. The majority (71%) of these central offices have an independent R&D budget, play a role in reviewing and evaluating the university research portfolio (93%), and help disseminating the results of completed projects to other parts of the organization (71%). Finally, 75% of the senior managers report having a document that describes the formal process for university project approval.

In terms of the innovation landscape, some of these companies belong to mature industries such as mining, paper and petro-chemicals and focus predominantly on process innovation. Other industries such as consumer electronics, biomed, and IT concentrate more on product development. Despite this diversity in the innovation landscape, the practices we report are applicable across sectors, with the exception of pharmaceuticals.

Pharmaceuticals were the only industrial sector found to have different practices. The pharmaceutical industry is on the boundaries between science and technology (Faulkner, 2002) and industry-university collaborations are more similar to the scientific collaboration process which is based on explicit sources of knowledge. The differences found might stem from their science-based approach for managing R&D, and the low yield rate characteristic of pharmaceutical research; according to the Food and Drug Administration (FDA), 96% of the molecular entities that reach the clinical trial phase fail (Food and Drug Administration, 2004). These failures occur at any stage of the clinical trial period which last on average 8 years (Adams and Brantner, 2003). Hence, this uncertainty may affect the project manager's judgment on the final impact the project had for the company. This causes problems with our methodology since we require project managers to provide an impact assessment. The decision was made to concentrate on the 86 technology-based projects, leaving the analysis of pharmaceutical projects for future research.

### 4.2. Company Motivations for Pursuing University Collaborations

Companies have different reasons for collaborating with universities. Project managers were asked why their company decided to do the research project with a university, and the answers are shown in Figure 3. The companies collaborate with universities mainly because university researchers: (1) bring new and original perspectives to problems, (2) are a valuable source of knowledge about new technology and its applications, and (3) have critical competencies relevant to the company's business needs.

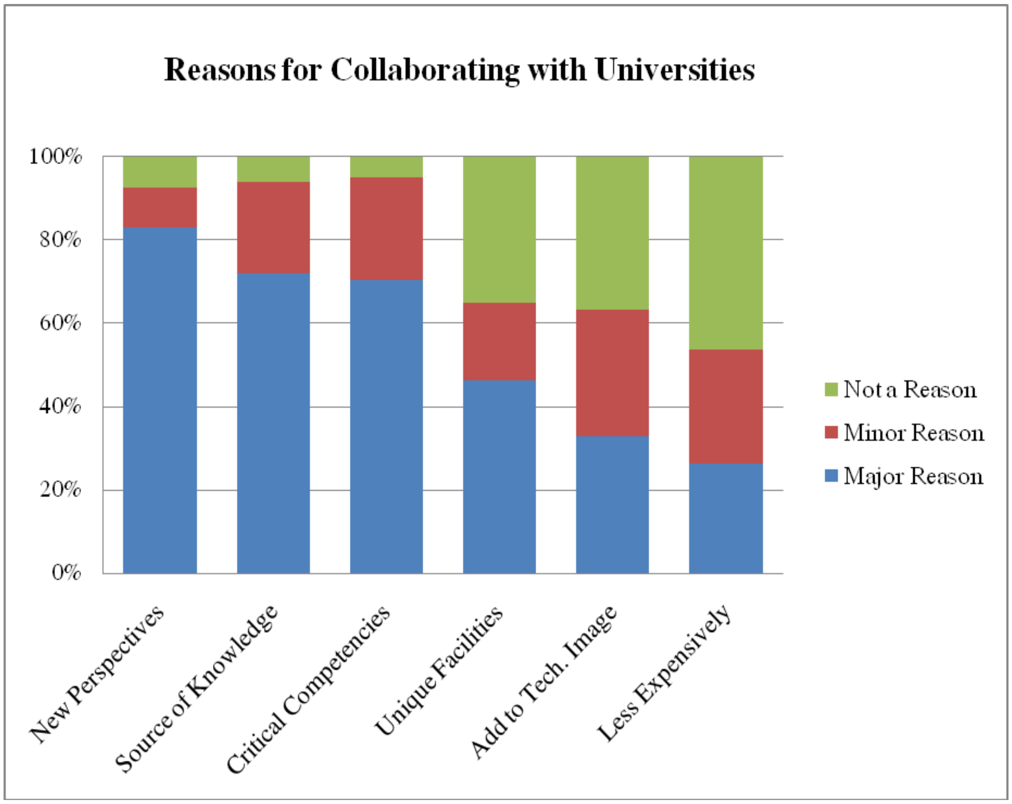


**Figure 3: Company Reasons for Collaborating with Universities**

### 4.3. Project Characteristics

This research analyzed an array of industry-university collaboration projects, with variations due to number of industrial participants, focus of the research, source of the funding, duration of the project, project budget, and number of people inside the company involved in the collaboration. The most common form of collaboration is the direct support of academic researchers by a single company. Within our study, 68% of the projects analyzed correspond to stand alone projects funded by a single company. More complex collaborations include multi-project arrangements, which were 21% of the cases analyzed, and the funding of university research laboratories through industry consortia, which were 11% of the cases analyzed.

Regarding the initiator of the project, 65% of the times it was the company. However, cases. However, 11% of the projects were initiated by the university researchers, the rest emerged from earlier joint work.

The focus of the research projects also varied. The cases analyzed are predominantly applied research projects (55%), followed by basic research (32%), and advanced development (13%).

Figure 4 presents the breadth and distribution of the length of the projects analyzed. On average, the projects lasted 31 months, with three years the most frequent length of commitment. Multi-project arrangements had longer collaboration timeframes than industry consortia or stand-alone projects.

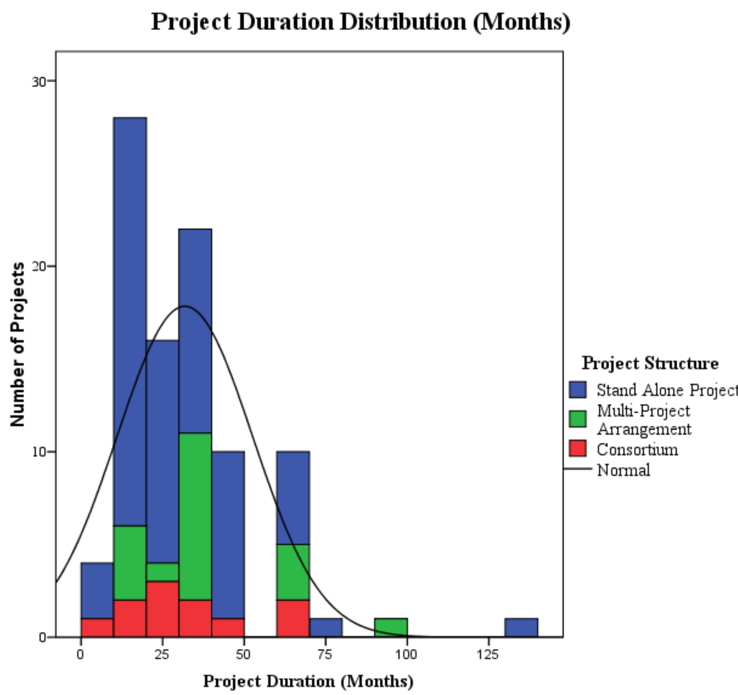


**Figure 4: Project Duration Distribution**

The project budgets also varied depending on the duration of the project. Longer collaborations had higher budgets. Consortia projects cost less per project than single or multi-project arrangements with a single university group. The source of the funding also mattered, in that projects involving government funding had higher budgets than projects entirely funded by companies.

Figure 5 presents a distribution of the annualized budget that each company contributed to the project. The distribution is positively skewed with 50% of the projects having an annual budget below USD$100,000, and a long tail of projects whose annual budgets surpassed that figure.

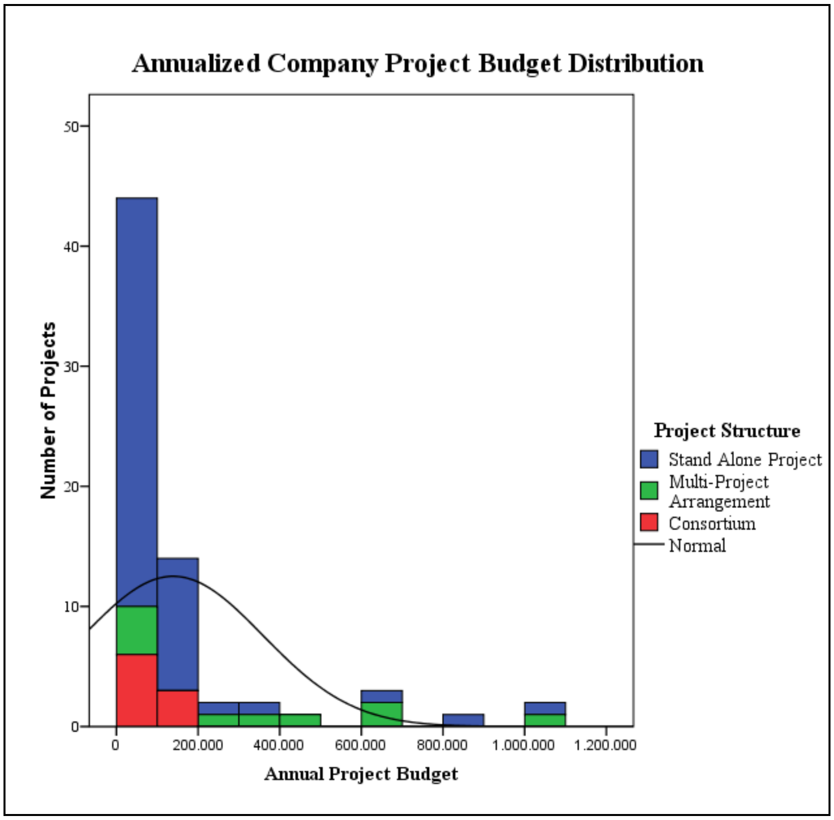


**Figure 5: Annualized Company Project Budget**

A final point of comparison is the people inside the company involved in the collaboration. Most of the project managers (57%) were full time researchers, who spent over 80% of their time on research and research management. Project managers understood the university context, 85% of them had a year or more of experience in a university research laboratory.

In addition to the project manager, 82% of the collaborations had other company personnel working on the project or another project linked to it. The number of Full Time Equivalents (FTEs) that participated in the research collaboration varied depending on the type of collaboration arrangement with consortia having fewer people involved than multi-project arrangements. On average, consortia involved 1 FTE, stand alone projects 1.4 FTEs and multi-project arrangements 8.7 FTEs. Neither the project's duration, nor its annual budget had a significant correlation with the number of people involved in the project, suggesting that many projects involved company personnel for a short period or intermittently. Figure 6 presents a distribution of the number of people that participated in projects.

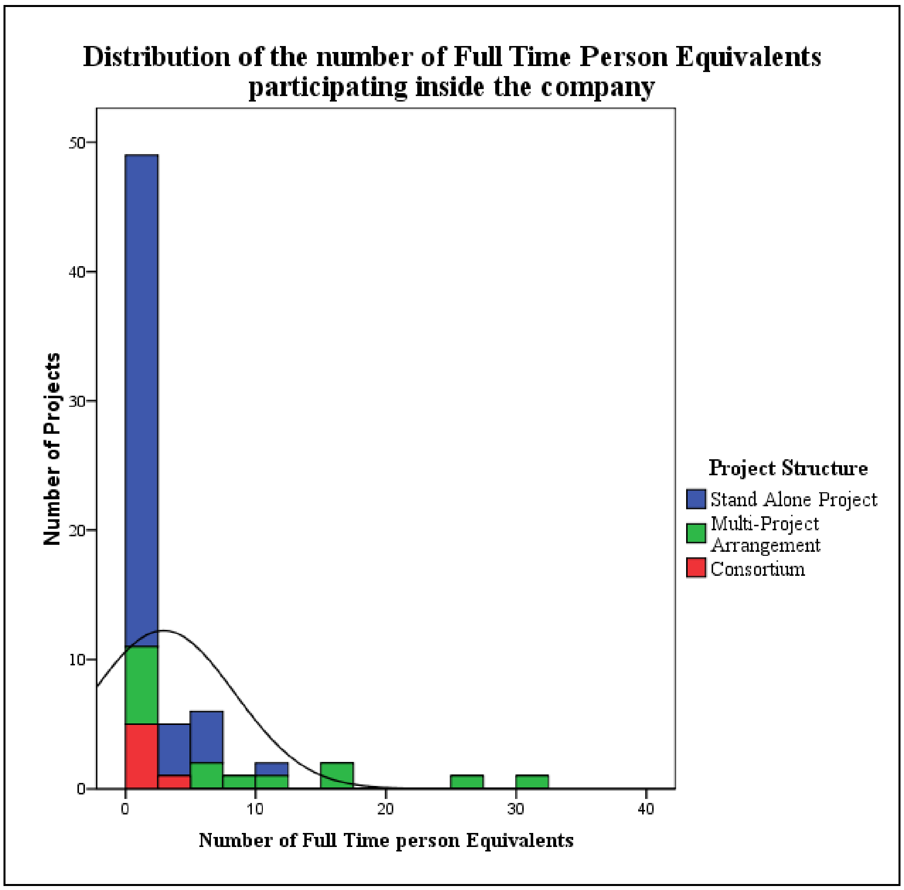


**Figure 6: Full Time person Equivalents involved in the Project**

## 4.4. Project Geographical Settings

In general, the participating companies selected the collaboration partners based on the merits of the university researcher and not on geographical proximity of the university.

There are obvious communication barriers imposed by different time zones, travel logistics, and communication costs. Despite these difficulties, however, the companies in the study scouted for collaborations on a truly global scale. As shown by Figure 7, nearly 50% of all the collaboration projects were done with universities located further away than 3 hours by plane.

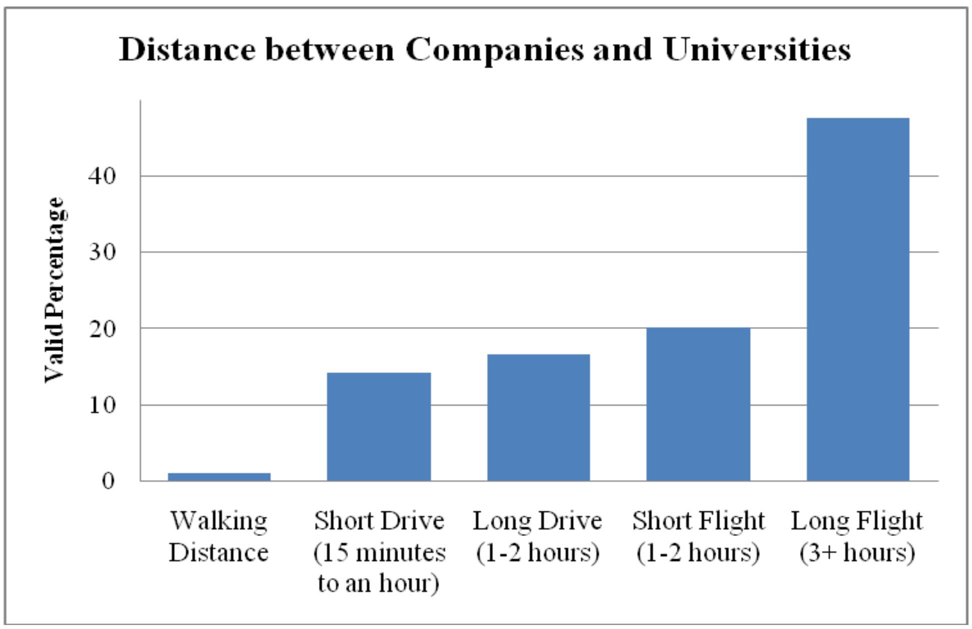


**Figure 7: Spatial distance between Companies and Universities**

## 5. Project Success Metrics

To determine practices that lead to a successful project, we first need to define the success metrics. To do this, we need to answer two important questions: (1) did the collaboration achieve what it set out to do; and (2) if so, what were the consequences for the company? For this reason, we visualize university collaborations as a two-step process in which we first evaluate the project's *outcome*, and then we evaluate the project's *impact* on the company.

This distinction between Outcomes and Impacts is a major aspect of this study (Calder, 2007). Most of the previous literature on industry-university collaborations stops in the analysis of the collaboration outcomes. That approach is incomplete since these outcomes should be judged by whether there are observable increases in the company's competitiveness. The framework here proposed is an effective tool for understanding the dynamics of the collaboration process.

### 5.1. Project Outcomes

Project outcome is a broadly defined term referring to the result of the project that creates both an opportunity, or avoids wasteful investment for the company. The definition thus includes negative findings, for example, information that finds that a strategy, technology or other possibility is not worth pursuing in the future. We used three main project outcome categories: Basic Knowledge, Applied Knowledge, and Intellectual Property.

Basic Knowledge refers to whether the collaboration project produced new ideas to be pursued, better understanding of one or more useful technologies, or other important knowledge to guide future activities. Applied Knowledge refers to whether the collaboration project found a solution to a problem, developed a method of analysis, enabled new products or processes, or produced any other tangible result. Intellectual Property refers to whether the collaboration project created new intellectual property, including software.

Project managers were asked to evaluate on a 1-2-3 scale the outcomes of the projects for each of the aforementioned categories, with a 1 given to projects with “no outcome,” a 2 given to projects with “minor outcomes,” and a 3 given to projects with “major outcome,” in other words with a clear and significant benefit to the company. The different scores for each of these three outcome categories were added to compose a single project outcome scale.

### 5.2. Project Impacts

The impact of a collaboration project refers to the successful exploitation of the research opportunity created by the project outcomes. Two questions coexist in this definition: (1) did anyone inside the company act in any way to exploit the opportunity offered by the outcomes; and (2) if so, was there a visible effect on the company’s competitiveness or productivity. Again, three categories were presented to project managers: Basic Knowledge, Applied Knowledge and Intellectual Property.

Basic Knowledge refers to whether new knowledge influenced company’s decisions or strategy (including decisions to not invest). Applied Knowledge refers to whether knowledge was put to use. Finally, Intellectual Property refers to whether steps were taken to obtain, protect or use any intellectual property that the company benefited from.

Project managers were asked to evaluate each one of these impact categories on a 1-2-3 scale, where 1 is given to the project with “little or no impact.” a 2 is given to the projects with “substantial impact,” and a 3 is given to the projects with “major impacts”—i.e., where there is an observable and generally agreed upon positive impact on the company’s competitiveness or productivity. The three scores were added to form a single impact scale.

### 5.3. The Outcome-Impact Gap

While an aspect of this study is to understand why projects were successful relative to their contractual goals, the study is even more concerned with why projects with good outcomes often do not have a major impact on the company. In the words of a project manager, speaking about his company's yield rate: "I would say realistically it's about 10-20%. We'd like it to be higher. There have been… [projects] where you'd think… it would've gone somewhere but it didn't for whatever reason."

Figure 8 presents the differences between project outcomes and impacts for the company.

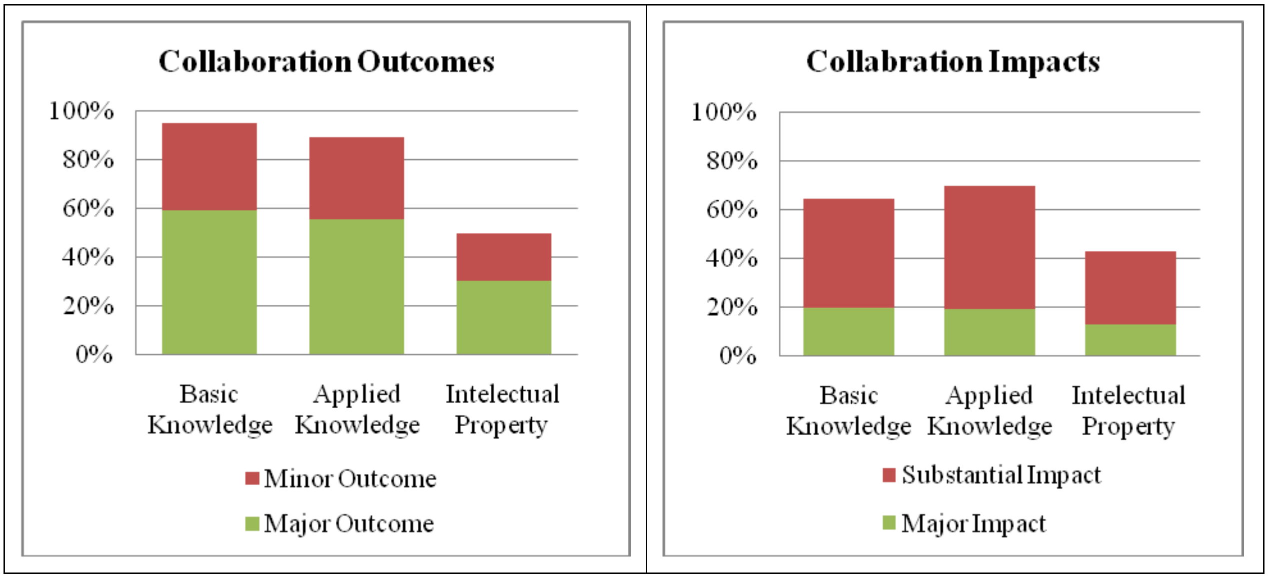


**Figure 8: Outcome-Impact Gap**

To test whether these differences are statistically significant, we performed a non-parametric Wilcoxon signed-rank test which allows the comparison of the paired medians of each category of outcome and impact (Wilcoxon, 1945). The results of this test indicate there is a statistically significant difference between the project outcome and impact scores (Table 1).

The value of the two-tailed asymptotic significance estimates the probability of obtaining a Z statistic that is as extreme or more extreme in absolute value as the one displayed, if there is no difference between outcomes and impacts. In this case, the value is below 0.05 which indicates the mean value of outcomes and impacts are different.

**Table 1: Statistical Analysis of the Outcome-Impact Gap**

**Wilcoxon Signed Ranks Test Statistics**

| | Base Knowledge (Outcome – Impact) | Applied Knowledge (Outcome – Impact) | Intellectual Property (Outcome – Impact) |
|---|---|---|---|
| Z | -5.127[a] | -5.604[a] | -3.951[a] |
| Asymp. Sig. (2-tailed) | .000 | .000 | .000 |

a. Based on positive ranks.

It could be argued that this outcome-impact gap is caused by: (1) undervaluation of the project's impacts by the project manager, (2) artificial overvaluation of the project's outcomes by the project manager, or (3) time-scale problem the projects might have potential impact yet to be exploited. We examine these points below.

First, to determine the accuracy of the project managers' responses, we asked senior technical officers to provide an independent judgment of the impact each project had on the company. These senior managers provided a single project impact evaluation score which was recorded on a 1-2-3 scale. We contrasted their responses with the project managers' sum of the Basic Knowledge, Applied Knowledge and Intellectual Property project impact evaluations. The senior technical officer and the project manager's assessment of project impact are correlated (r=.472, p=.000). In addition to this correlation, we measured whether the project manager's average impact assessment was different in magnitude from the senior technical officers' assessment. If this were true, then the two-tailed asymptotic score of the Wilcoxon signed-rank test will be below .05. The test results presented in **Error! Not a valid**

**bookmark self-reference.** indicates there is no evidence to sustain that project managers and senior technical officers have different impact assessments.

**Table 2: Senior Technical Officer and Project Manager Impact Evaluation**

**Wilcoxon Signed Ranks Test Statistics**

| | Project Impact Assessment (Project Manager- Senior Manager) |
|---|---|
| Z | -.057[a] |
| Asymp. Sig. (2-tailed) | .955 |

a. Based on negative ranks.

Second, project managers may artificially exaggerate the appraisal of the project's outcome since this could be viewed as a reflection of their performance. However, if this were the case, they would also tend to exaggerate the valuation for the project's impact since this also reflects on their performance. As already shown in table 2, the project manager's and senior technical officers share the same impact assessment. Hence, there is no reason to expect project managers are providing exaggerated information about the project's outcomes.

Finally, it could be argued that the low impact scores are caused by different evaluation time horizons. A project might have initially low impact, but in the long run could yield a high impact for the company. Thus, we asked project managers to evaluate whether they expect the projects to have a long-term impact on the company, and if so, to estimate on a 1-2-3 scale the long-term impact for the project.

The result was that 51% of projects expected to have a long-term impact for the company. The project managers were also asked to estimate how many years would it take to achieve this long-term impact. On average, project managers expected these impacts to occur in the next 5 years.

Out of the projects expected to have a long-term impact, we created a new impact scale composed of the maximum short-term and long-term impact scores. The short-term impact is calculated using the average value of the Basic Knowledge, Applied Knowledge and Intellectual Property scores (1-2-3). The long-term impact score is obtained from the project managers' answer to the question "*how much overall impact in the long-term do you expect this project to have on your company?*" Project manager answers were recorded on a 3-point scale. Both short-term and long-term impact scores have the same answer categories where a 1 was given to the projects they expected to have little to no impact, a 2 was given to the projects that were expected to have a substantial impact, and a 3 was given to the projects that were expected to have a major impact in the future.

We compared this impact scale with the average value of the Basic Knowledge, Applied Knowledge, and Intellectual Property outcome scores and the differences between outcome and impact measures are presented in Figure 9.

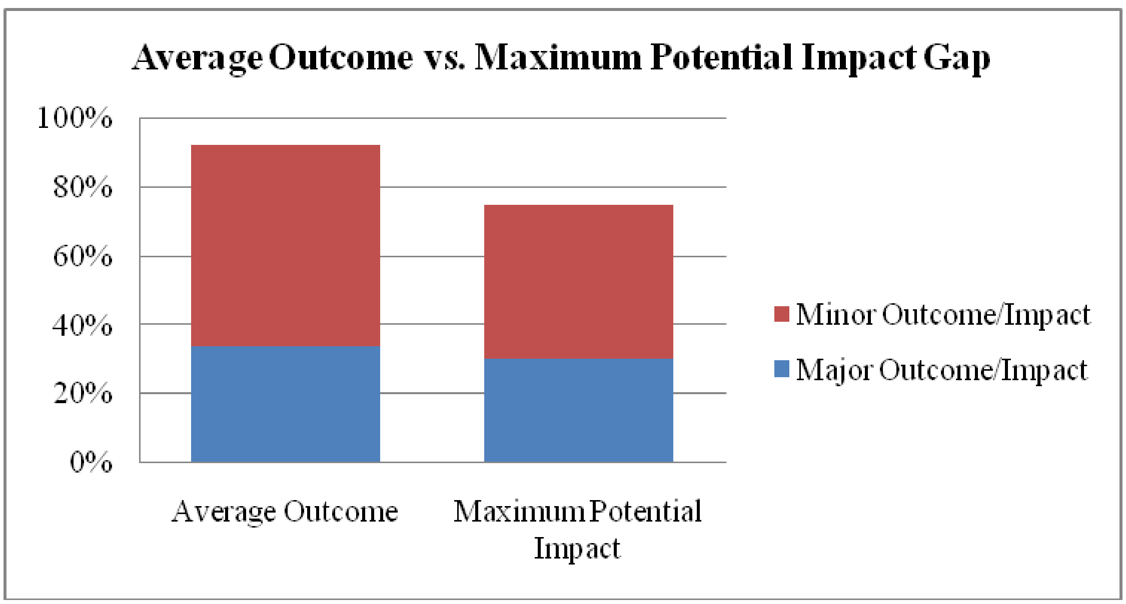


**Figure 9: Average Outcome vs. Maximum Impact Gap**

Even after selecting the best-case scenario for the research impact assessment, there is still a statistically significant outcome-impact gap as evidenced by the low two-tailed asymptotic score of the Wilcoxon signed-rank test presented in Table 3. The long-term impact measure is an optimistic approximation of the real impact and we thus predict that the outcome-impact gap will be wider.

**Table 3: Statistical Analysis of Maximum Long-term Impact**

**Wilcoxon Signed Ranks Test Statistics**

| | Outcome-Impact Gap (Average Outcome-Maximum Potential Impact) |
|---|---|
| Z | -4.851[a] |
| Asymp. Sig. (2-tailed) | .000 |

a. Based on negative ranks.

From the arguments just presented, it is our conclusion that the outcome-impact gap, is not a result of an artificial overvaluation of the project's outcomes by the project manager, or an undervaluation of the project's impacts by the project manager, or an undervaluation of the project's impact due to time-scales. Projects with good outcomes are not finding their way into becoming company impacts.

## 6. A Industry-University Collaboration Model

Figure 10 is a model representing the different stages and interactions that occur during industry-university research collaborations. The model has been developed from our observations that not all projects with good outcomes translate into an impact on a company's competitiveness and productivity. Our best practices search is guided by analyzing the interactions between 1) the project manager and the company's professional community (blue arrows), 2) the project manager and the university researcher (green arrows), and 3) the university researcher interactions with other company personnel (red arrows).

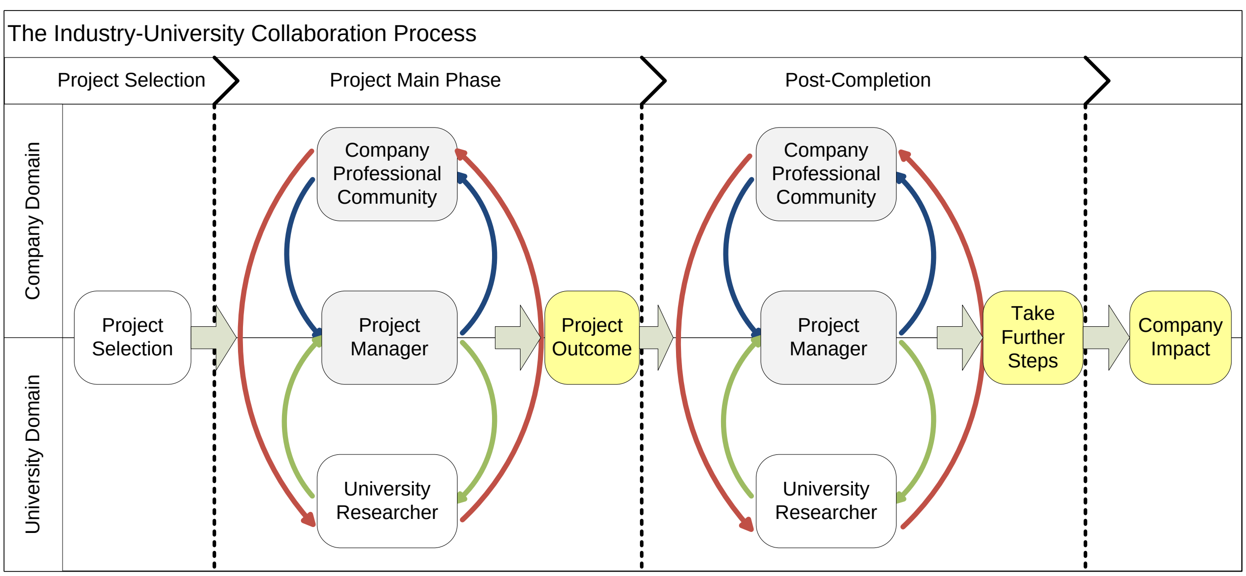


**Figure 10: The University Industry Collaboration Model**

To understand the model, we first focus on the project's success metrics (in yellow, Figure 10). As explained in Section 4, there are three important success metrics: "Project Outcome," "Taking Further Steps," and "Company Impact."

"Project Outcome" is the result of the collaboration which creates an opportunity for the company. "Taking Further Steps" refers to whether anyone inside the company took any action to exploit the opportunities created by the project’s outcome. Finally, “Company Impact” refers to the degree to which the collaboration translated into increases in the company’s competitiveness and/or productivity. Hence, our best practices search will concentrate on the management activities that influence these three metrics.

As expected, it is easier to act upon projects that already have good outcomes. This is evidenced by the high correlation between “Project Outcome” and “Taking Further Steps” ($r=.639$, $p<.001$), and the high correlation between “Taking Further Steps” and “Company Impact” ($r=.769$, $p<.001$). Not all projects with good outcomes translate into high impacts for the company, however, and thus we focus on understanding the practices that (1) increase the likelihood of obtaining good project outcomes, (2) encourage people inside the company to act upon the opportunities presented by the project’s outcomes, and (3) directly affect the final impact the project has on the company’s competitiveness and productivity. We present three propositions about these practices in the following section.

## 7. Research Propositions

Collaborative research can be visualized as a "full contact sport" where university and industry researchers *create* and *exchange* knowledge through informal personal interactions. This premise is supported by the technology management literature, which explains how technology is exchanged across organizational boundaries (e.g., Allen, 1977, Ancona and Caldwell, 1992; Reagans and McEvily, 2003), and the knowledge creation literature, which explains the human activities that enable the creation of knowledge (e.g., Nonaka, 1994; Nonaka and Takeuchi, 1995). From these literatures we derived three propositions about factors that increase the knowledge flow between industries and universities, thus reducing the outcome-impact gap. The propositions and the supporting literature are explained in the following subsections.

### 7.1. The Nature of Knowledge Exchange

Literature on technology management describes *boundary spanning* as the primary process through which technology is exchanged across organizational lines (Allen, 1977). Boundary spanning is an activity is performed by key individuals, called boundary agents, who reach across organizational structures, transferring knowledge through informal technical communications (Allen, 1977).

Boundary spanning activity has its origins in the concept of indirect information flow, as first described in a study of the effect of newspapers and radio on voter decisions (Allen, 1977). It was discovered that media did not affect voter decisions directly, but instead affected a particular group of individuals, the "opinion leaders," who then influenced the rest of the voters (Katz and Lazarzfeld,1964). In an analogous form, boundary agents act as the "opinion leaders" of technical and scientific knowledge (Allen, 1977). They tap into professional networks and knowledge communities to extract valuable ideas for technological advancements. The evolution of the boundary spanning concept is discussed in the thesis by Calder (2007).

Boundary spanning is particularly important for technology based institutions since engineers often develop particular vocabularies and communication schemes which are shaped by their work structure, social relations, history and values (Allen, 1977). These communication schemes help team members to communicate information faster and more accurately, but this specialization often presents problems when internal groups try to transmit or receive information from different organizations (Allen and Cohen, 1969). Boundary agents solve this communication problem by performing a translating role in the exchange of knowledge, processing, encoding, and adapting new information to the organization requirements so it can be understood and assimilated by different groups.

There are two key requirements for becoming a boundary agent. First, an individual must be highly proficient in the technical field, with a good understanding of the technology. Second, he or she needs to be an "internal communication star," which is the name given to the people who are the most frequently approached by their peers for technical advice (Allen and Cohen, 1969). Technical expertise is necessary for understanding the complexity of scientific and technological knowledge and being perceived as a technical expert helps a boundary agent to become an internal communication star.

The diversity of a boundary agent's network, i.e., how many different knowledge pools and boundaries he or she can tap into, has been shown to facilitate the knowledge transfer process (Ancona and Caldwell, 1992; Reagans and McEvily, 2003; Reagans and Zuckerman, 2001). People who are exposed to diverse audiences have a better chance of learning how to communicate complex ideas than people who are bound always by the same group. In addition, network diversity provides more opportunities for finding new knowledge (Hansen, 1999).

Boundary agents, however, cannot be designated; people who are appointed to perform this role often fail because a necessary condition is that boundary agents must first gain peer recognition (Nochur and Allen, 1992). This limitation presents policy implications for firms: companies must identify their boundary agents, acknowledge their role and promote their spanning activity since these agents become the technological gatekeepers of the firm (Allen and Cohen, 1969).

Boundary spanning explains how people acquire knowledge from external sources and disseminate it inside the organization (Allen, 1977). We suggest that this activity can be extended to explain how project managers of industry-university collaborations acquire and disseminate the knowledge created by the collaboration. Hence, we propose:

**Proposition 1** The inward boundary spanning activity of the company project manager has a positive effect on the collaboration's outcomes and impact.

Boundary spanning, however, does not explain all the interactions taking place during industry-university collaborations. As described by Allen (1977), one of the limitations of boundary spanning is that it takes the existence of external knowledge as a given. Hence, the task of the boundary agent is to scan external sources, acquire knowledge, and disseminate its content inside the organization. This process suggests a unidirectional flow of knowledge from the external source to the company.

Industry-university collaborations, however, are different. They require an active engagement of both parties since the collaboration is aimed at creating knowledge that does not exist. This suggests a bidirectional flow of knowledge between the university and industry researchers. The analysis here is intended to capture the interactions that enable the creation of such knowledge.

### 7.2. Tacit and Explicit Knowledge Creation

Knowledge is a broad term that encompasses not only information, but also skills and expertise. Scholars of knowledge theory distinguish two types of knowledge: "explicit" and "tacit" (Polanyi 1966). *Explicit knowledge* is the type of knowledge we absorb through conversations or reading because it can be verbalized and codified. A central characteristic of explicit knowledge is that it can be transmitted through publications and can be stored in books or databases for later retrieval. *Tacit knowledge*, in contrast, is difficult to codify. It is acquired through personal interaction such as spending time in somebody's company or working in a common surrounding (Nonaka and Takeuchi, 1995). An illustration is an apprentices who learns by spending time with his or her masters for example a violin craftsman who learn how to manufacture and tune instruments by on-the-job experience. Tacit knowledge is characterized by the notion that "we can know more than we can tell" (Polanyi, 1966). Tacit and explicit knowledge are complementary entities (Nonaka, 1994).

The way in which tacit knowledge is transmitted highlights the importance of close and frequent interactions for creating knowledge through collaborations. Hence, we propose:

**Proposition 2** Frequent bidirectional interactions between university researchers and company personnel positively affects the collaboration's outcomes and impact.

Companies amplify the creation of knowledge by incentivizing people to reach out of the organization to interact with external stakeholders such as customers, providers, and universities (Nonaka and Takeuchi, 1995). This active outreach is enabled by the existence of personal relationships between individuals (Nonaka and Ichijo, 2007).

Personal relationships can also be classified according to their strength. There are weak ties, and strong ties (Granovetter, 1973). A weak tie denotes remote and sporadic relationships between individuals. Weak ties are effective for searching new knowledge and for transferring explicit knowledge because they bridge different groups and their knowledge pools (Hansen, 1999). However, weak ties make it difficult to exchange complex types of knowledge, which are often tacit in nature, because the exchange of knowledge requires frequent personal interactions.

Strong ties are characterized by an emotional closeness and a high degree of communication between individuals (Hansen, 1999). Strong ties are effective for the transfer of complex knowledge which is often tacit in its nature.

There is abundant evidence that strong personal relationships facilitate the creation and exchange of knowledge. Qualitative studies report that company managers, university technology transfer administrators, and university scientists all mention strong personal relationships as an important factor affecting industry-university technology transfer (Siegel et al., 2004). There is also quantitative evidence on how the strength of an interpersonal relationship positively affects the exchange of knowledge (Uzzi, 1997; Hansen, 1999; Reagans and McEvily, 2003). The literature shows that personal relationships are important because: (1) knowledge is embedded in the social network; (2) strong relationships aid the transfer of tacit knowledge which requires a close personal interaction; and (3) strong relationships grant access to knowledge that, despite being explicit, is not necessarily public (Maznevski and Athanassiou, 2007). Hence, we propose:

| | |
|---|---|
| **Proposition 3** | Collaborations where there are strong relationships between the university and industry researchers yield higher outcomes and impact for the company. |

## 8. Results and Analysis

This section presents a statistical analysis of how the three research propositions affected the success metrics that were presented in Section 4. The results and their discussion are shown in the following subsections.

### 8.1. Proposition 1: Results and Analysis

To test the first proposition: "the inward boundary spanning activity of the company project manager has a positive effect on the collaboration's outcomes and impact," a single scale was created composed of seven questions found in the F Section of the survey (see Table 4). These seven questions relate to the project manager's ability to interact with other colleagues during the collaboration. Project managers were asked to indicate the frequency (on a 4-point scale) at which they performed the following activities:

**Table 4: Project Manager Boundary Spanning Activity Scale**

| "How often did you do the following during the project?" |
|---|
| F6. Explored connections between this project and other research trends and developments with others in the company concerned with science and technology. |
| F7. Met and discussed the project with professionals in a business unit or department. |
| F8. Solicited suggestions from technical professionals in the company about how the project would better fit their needs. |
| F9. Told stories to other company professionals about interesting experiences with methods, lessons or discoveries the project had developed. |
| F11. Telephoned the university researchers to have unscheduled discussions. |
| F12. Brought the project up in conversation with other individuals involved in R&D. |
| F13. Used ideas or results from this project in discussions about future technologies the company might consider. |

The scores of these practices were added to form a scale. To test this scale's reliability, we calculated the Cronbach's alpha, which measures the internal consistency of a scale based on the average inter-item correlation. As a general rule, scores above .6 indicate the questions in the scale are reliable, which means the variability in the responses to these questions are caused by different opinions of the respondents and not because the questions are confusing or subject to multiple interpretations (Cronbach, 1951). The score for the three items is .831, which indicates this scale is reliable. No question can be removed without reducing the scale's reliability.

Our results support Proposition 1. The frequency of the boundary spanning activity of the project manager is positively correlated with the project's outcomes ($r=.267$, $p<.05$), with whether people inside the company took steps to exploit those outcomes ($r=.380$, $p<.001$), and with the overall project impact ($r=.300$, $p<.001$).

**Discussion:**

The correlation results indicate there is a statistically significant relationship between the boundary spanning activity of the project manager and the impact the project has on the company. The strength of this relationship can be interpreted by analyzing the square of the correlation which is .09. This means 9% of the variation in the impact result is explained by the boundary spanning activity of the project manager. This number is significant considering the breadth and diversity of projects analyzed and the low yield rate of university collaborations: less than 20% of the collaborations achieved a major impact for the company (see Section 4.3). In addition, the boundary spanning activity of the project manager is not the only factor affecting the impact of university collaborations. As we continue to analyze the research propositions, we expect to find additional activities that contribute to the project's impact.

Another important finding is that boundary spanning activity is positively correlated with the project's outcomes and with whether people inside the company took steps to exploit those outcomes. As project outcomes and taking steps are positively correlated with the project's impact ($r=.661$, $p<.001$ and $r=.769$, $p<.001$ respectively), the overall effect of boundary spanning on the project's impact may be even higher since there could be indirect contributions for which we do not account.

The positive correlation between boundary spanning and project's outcomes indicates this activity should start even before the project is completed. As one of the project managers we interviewed expressed: "Ideally [we] should have an ´apply on the fly' approach. As soon as the university researchers start giving research findings back, the company should start integrating those findings [into the R&D pipeline] immediately." Therefore, boundary spanning should be a continuous process that begins during the project and continues afterward to make sure the research was appropriately considered for possible action. Put another way, project managers are responsible for the inward representation of the outcome results.

### 8.2. Proposition 2: Results and Analysis

To test the second proposition: "frequent bidirectional interactions between university researchers and company personnel positively affects the collaboration's outcomes and impact," a single scale was created composed of three questions found in the F Section of the survey (see Table 5). Project managers were asked to evaluate the frequency at which the university researcher visited the company and met with different internal groups. The answers were recorded on a 4-point scale:

**Table 5: University Researcher-Company Personnel Interaction Scale (Frequency)**

| “How often did researchers from the university do each of the following?” |
|---|
| F1. Visited your organization and met the program manager. |
| F2. Visited the company and spoke to professionals in a research group about the research. |
| F3. Visited the company and discussed applications or other uses with professionals in the business unit. |

The scores of these practices were added to form a scale. To test this scale’s reliability, we calculated the Cronbach’s alpha. The score for the three items is .862, which indicates this scale is reliable. No question can be removed without reducing the scale’s reliability.

The results support Proposition 2, namely that frequent personal interactions between university researchers and company personnel are positively correlated with the project’s outcomes ($r=.398$, $p<.001$), with whether people inside the company took further steps to exploit those outcomes ($r=.298$, $p<.01$), and with the overall project impacts ($r=.323$, $p<.01$).

**Discussion:**

The correlation results indicate the frequency of the university researcher’s interaction with company personnel explains 10% of the variation in the project’s impact. There might be additional indirect contributions to the project’s impact explained by the positive correlations between the university researcher’s interaction with company personnel and the project’s outcomes and whether people took steps to exploit those outcomes.

The university researcher’s interaction with company personnel is also positively correlated with the project manager’s boundary spanning activity ($r=.340$, $p<.01$). This suggests that project managers perform a cross-pollination task by retrieving information from their colleagues and sending it to the university researchers as a feedback mechanism. Therefore, the knowledge flows will be bidirectional. To test this idea we need to analyze the stage of the project in which these contacts happened, and whether companies facilitated this interaction.

We created a new scale composed of four questions drawn out of the W Section of the survey (see Table 6) and asked project managers to indicate all the project phases in which the university researchers interacted with different company personnel.

**Table 6: University Researcher Interactions by Project Phase**

| "Please check all stages when the activity occurred."<br>( Planning and Selection Phase, Main Phase, Post-Project-Completion, or Never) |
|---|
| W4. When did university researchers visit the company? |
| W6. When did university researchers make presentations to interested technical professionals other than you? |
| W7. When did university researchers meet informally with professionals in a business unit? |
| W14. When were professionals from other functional areas (marketing, manufacturing, sales, design) brought into meetings with university researchers? |

We grouped the answers by project stage and added the number of positive responses to form three different scales: planning and selection, main phase, and post-project-completion contact scales. To test these scales' reliability, we calculated their individual Cronbach's alpha score. The alpha score for the planning and selection phase scale is .538; the alpha score for the main phase scale is .720; and the alpha score for the post-project-completion scale is .805. Since the planning and selection phase scale did not pass the .6 bar, we will concentrate on the main phase and post-project completion interactions only.

Our results indicate that personal interactions between the university researcher and company personnel occurred predominantly during the main phase of the project (Table 7).

**Table 7: Average University Researcher's Interaction by Project Stage**

| | N | Min. Score | Max. Score | Sum | Mean | Std. Deviation |
|---|---|---|---|---|---|---|
| Main phase contacts | 84 | 0 | 4 | 202 | 2,40 | 1,38 |
| Post-project-completion contacts | 83 | 0 | 4 | 88 | 1,06 | 1,38 |

Main phase interactions are positively correlated with the project's outcomes (r=.368, p<.001), and impact (r=.352, p<.01). In addition, these main phase interactions are positively correlated to the project manager's boundary spanning activity (r=.393, p<.001), which confirms bidirectional knowledge flows have an effect on outcomes and impacts during a collaboration.

### 8.3. Proposition 3: Results and Analysis

To test the third proposition: "collaborations where there are strong relationships between the university and industry researchers yield higher outcomes and impacts for the company," a single scale was created composed of seven questions found in the T Section of the survey (see Table 8). Project managers were asked to indicate their level of agreement or disagreement (on a 4-point scale) with each of the following statements about people during the project:

**Table 8: Quality of Relationships Scale**

| "Here are some statements about the people on the project during the project. Please circle a number to indicate your level of agreement or disagreement with each statement." |
|---|
| T4. "It was hard to get university researchers to meet and talk about progress" (reverse score) |
| T7. "Once the project was well underway, senior university researchers were not attentive to the project." (reverse score) |
| T8. "You and the research team got along well personally." |
| T9. "Meetings between you and the university researchers were successful in covering the most important issues." |
| T10. "The researchers were more interested in publishing than the project's agreed-upon purpose." (reverse score) |
| T11. "In general the researchers seemed to feel a strong obligation to meet company needs." |
| T12. "The relationship you had with the university researchers felt like a partnership exploring an area together." |

The scores of these practices were added to form a scale. To test this scale's reliability, we calculated the Cronbach's alpha. The score for the three items is .790, which indicates this scale is reliable. No question can be removed without reducing the scale's reliability.

The results support Proposition 3, that the quality of the relationships between the project manger and the university researcher is positively correlated with the project's outcomes ($r=.407$, $p<.001$), with whether people inside the company took steps to exploit these outcomes ($r=.345$, $p<.01$), and with the project's final impact ($r=.332$, $p<.01$).

**Discussion:**

The correlation results indicate the quality of the relationship between the company project manager and the industry researcher explains 11% of the variation in the project's impact. Furthermore, there might be additional indirect contributions to the project's impact explained by the positive correlations between the quality of the relationship and the project's outcomes and whether people took steps to exploit those outcomes.

There is a positive correlation between strong relationships and the university researchers' contacts with company personnel during the main phase of the project ($r=.327$, $p<.01$), and with the project manager's boundary spanning activity ($r=.289$, $p<.01$). These findings confirm the importance of cultivating strong relationships for increasing bidirectional knowledge flow during university collaborations.

The three propositions confirm the importance of (1) the project manager's boundary spanning activity, (2) the university researcher frequent interaction with company personnel, and (3) the quality of the relationships between the researchers. These three factors combined are able to explain 33% of the variation in the project's outcomes, and 23% of the variation in the project's impact, as evidenced by the results regression analysis with project outcomes and impact as dependent variables.

## 9. Additional Findings

We also analyzed how the industrial context affected the collaboration's results. It was found that the research alignment and the duration of the project were positively correlated with the collaboration's success metrics of Section 4. These findings are given in the following subsections.

### 9.1. Research Alignment

Industry-university collaborations need to be aligned with the company's strategy, R&D pipeline, and business practices. If not, there is high risk of investing in projects that will end up sitting on the shelf.

There are three aspects of the collaboration that need to be aligned: the project, the project manager, and the university researcher. Alignment of the project refers to the degree to which the collaboration supports and is supported by the company's R&D strategy. For example, company R&D labs need to have some internal capacity to take advantage of external R&D, which is referred to as their absorptive capacity (Cohen and Levinthal, 1990). Alignment of the project manager refers to whether he or she was given correct incentives and support to manage the collaboration. Finally, alignment of the university researcher refers to the degree to which he or she understands the company's goals for the project and are able to tailor the research to fit the company's needs. This includes understanding the business setting, company practices, and the way in which the research fits company strategy.

#### 9.1.1. Alignment of the Project

We asked project managers whether the collaboration complemented other R&D taking place within the company (Question T15). Their answers were recorded on a 4-point agree/disagree scale. The results indicate that projects that complement other R&D are positively correlated with the collaboration's outcomes ($r=.365$; $p<.001$) and impact ($r=.355$; $p<.001$).

Another measure of project alignment is the company motivation for pursuing external research. We asked project managers to evaluate the reasons their company had to pursue the research outside the company (see Table 9). Their answers were recorded on a 3-point scale.

**Table 9: Motivations for Pursuing External Research**

| "Why did your organization decide to do this research outside the company?" University researchers… |
|---|
| S2a. Are able to do certain things less expensively. |
| S2b. Bring new and original perspectives to problems |
| S2c. Add to the company's image of technological leadership. |
| S2d. Have access to unique facilities. |
| S2e. Are a valuable source of knowledge about new technologies and applications |
| S2f. Have critical competencies relevant to the company's business needs. |

As mentioned in Section 4.2, the most cited motivations expressed for collaborating with universities were, to bring new and original perspectives to problems, to gain access to a valuable source of knowledge about new technologies and applications, and to gain access to critical competencies relevant to the company's business needs. These motivations are positively correlated with the project manager's boundary spanning activity (see Table 10).

**Table 10: Research Motivation's Effect on Project Manager Boundary Spanning Activity**

| "Why did your organization decide to do this research outside the company?" University researchers… | Correlation with Project Manager Boundary Spanning Activities |
|---|---|
| Bring new and original perspectives to problems | $r=.350$ ; $p<.01$ |
| Are a valuable source of knowledge about new technologies and applications | $r=.391$; $p<.001$ |
| Have critical competencies relevant to the company's business needs. | $r=.233$ ; $p<.05$ |

Finally, we asked project managers to rank the importance of their organization's leadership in the research project's area. Four options were presented: (1) critically important—a core capability, science and technology leadership in this area is central to the company's mission; (2) important—company needs to be internally strong in this area; (3) somewhat important—capabilities in this area are available externally, but the company needs some internal strength in this area; and (4) not very important—capabilities in this area are readily available outside the company. The results indicate that projects in an area perceived as important for the company were highly correlated with the impact they produced on the company ($r=.383$; $p<.001$).

### 9.1.2. Alignment of the Project Manager

We asked project managers whether the result of the collaboration project was/will be part of their performance review or otherwise affect their careers (Question T18). This practice was positively correlated with whether people inside the company took steps to exploit the opportunities offered by the project's outcomes ($r=.285$, $p<.05$), and with the project's impact ($r=.324$, $p<.01$).

If companies want to link collaboration outcomes to the performance measurements, they should also provide project managers with adequate time to run the collaboration. We asked project managers whether they had too many other responsibilities to spend as much time as they would have liked on the project (Question T13). The results indicate that having inadequate time is negatively correlated with the quality of the relationships between the research groups ($r=-.258$; $p<.05$) and also negatively correlated with the project's outcomes ($r=-.250$, $p<.05$).

### 9.1.3. Alignment of the University Researcher

We tested the alignment of the university researcher through three questions. One was the evaluation of whether the university researchers had an understanding of the company's goals for the project (Question T5). A second was evaluating whether the project required substantial understanding of company practices (Question T14). The third was evaluation of the university researcher's ability to link the research to the industry's practices (Question T17). All answers were recorded on a 4-point agree/disagree scale.

The results indicate the university researcher's level of understanding of company goals for the project is positively correlated with the project's outcomes ($r=.268$, $p<.05$) and impacts ($r=.276$, $p<.05$). In addition, projects that require a substantial understanding of company practices are positively correlated with the project manager's boundary spanning activity ($r=.243$, $p<.05$), and with the university researcher's contacts with industry personnel ($r=.328$, $p<.01$). Finally, the university researcher's ability to link research results to company practices is positively correlated with quality of the relationships they established with the project manager ($r=.567$, $p<.001$).

A proxy to test the university researcher's understanding of company practices is whether they had previously consulted in the same or a similar industry (Question T16). This previous experience is positively correlated with the quality of the relationships between the researchers ($r=.233$, $p<.05$), and also with the project's outcomes ($r=.233$, $p<.05$).

## 9.2. Project Duration and Budget

We analyzed the effect of the project's duration on the outcomes and impacts of the collaboration (Question D9) using the logarithm of the number of months to control for the skewness in the project's distribution. We also analyzed whether the project's annual budget had any effect on the project's success metrics.

The results indicate the duration of a collaboration is positively correlated with the project's outcomes ($r=.396$, $p<.001$). On the contrary, the project's budget, did not have any significant correlation with the project outcomes ($r=.083$, $p>.05$) or impact ($r=.048$, $p>.05$).

The duration of the project was also positively correlated to the frequency of interactions between university researchers and company personnel ($r=.367$, $p<.001$), and with the project manager's boundary spanning activity ($r=.300$, $p<.01$). These findings are consistent with previous studies that have found positive effects of time on knowledge transfer (Allen, 1977). Over a prolonged period of time, people utilizing different communication schemes can understand their communication differences, and thus act on the translation problems that arise. Hence, longer collaboration timeframes help researchers to develop a common understanding of the research problem, as well as a common vocabulary in which to communicate the results. In addition, over time weak personal ties can be transformed into strong ties, enabling the transfer of complex knowledge between collaborating agents (Hansen, 1999).

## 10. Summary of Findings

Throughout the thesis, we discussed three propositions that were shown to positively correlate to the outcomes and the final impact of the projects. The results from these propositions and additional research findings can be summarized as follows.

### 1. Not all Industrial Sectors Behaved Similarly when Collaborating with Universities

The pharmaceutical industry had different practices than the rest of the industries of the dataset. These differences may stem from the differences between science- and technology-based research and the long trial periods of pharmaceutical research, but the specifics are not currently known.

### 2. Knowledge Flows During Collaborations are Bidirectional

The boundary spanning activity of the company project managers contributed to the success of the collaboration in two ways. First, they performed a cross-pollination task by retrieving information from the company's technical community and sending it to the university researchers as a feedback mechanism for keeping the research aligned. In addition, project managers contributed to the diffusion of the research results inside the company.

> "It is important that the project managers are extroverted. They need to enjoy interacting with people. [One of our] team members had a business card that said 'hunter-gatherer.' That is precisely the mentality that is needed in this work. Project managers need to be continuously scouting for new technologies."
>
> Vice President of External Research

Knowledge exchanges are important during the project, but the project does not end when the contract is completed. Project managers should feel a responsibility for the inward representation of the research results. This is a continuous process that begins during the project and continues afterward to make sure the research was carefully considered for possible action. This is the most important practice for bridging the outcome-impact gap.

> "It is important to have someone inside the company fully dedicated to the project. Someone has to take ownership of the project. If not, it is going to sit on the shelf and who knows if anyone is going to remember to bring it back."
>
> Project Manager

### 3. Frequent Formal and Informal Interactions Enhance the Creation of Knowledge

The frequency at which the university researcher visited the company and met with other company personnel, in addition to the project manager, was positively correlated with the outcomes and impacts these projects produced. These contacts, both formal and informal, were especially important in the main phase of the project's lifecycle.

> "If I had to start all over again, I would have brought the business people into the meetings with the university researchers, in the planning and selection phase of the project."
>
> Project Manager

Frequent personal interactions are important since they aid in the transfer of tacit knowledge. Thus, two useful practices are building awareness of the collaboration inside the company, and assigning more people to the project since this provides additional points of contact for the university researchers to exchange knowledge.

> "[In our company] now there is a push to incorporate more people into meetings with the university researchers to have multiple focal points to increase the diffusion of knowledge."
>
> Project Manager

### 4. Strong Personal Relationships Enhance the Flow of Knowledge

The quality of the relationships between the university researcher and the project manager is positively correlated with the overall success of the project. Strong personal relationships enable the exchange of tacit knowledge, which requires close personal interactions.

> "What is critical is the heavy involvement from the industry side. Both research teams need to merge, you need to make the university researchers part of your team. In a way, they can be considered as a virtual arm of your research team."
>
> Project Manager

We found that 77% of the collaboration projects emerged through a previous relationship with the university group. These relationships, more than institutional, are formed by personal ties. Hence, a good practice for companies is to start the search for possible collaboration partners within the company's employee network.

> "Good relationships were a key to success. Personal relationships need to go beyond the business."
>
> Project Manager

### 5. The Collaboration Project, the Project Manager and the University Researcher all need to be Aligned

We found that a common characteristic of successful collaborations was the alignment of the project and the university researchers with the R&D portfolio and company strategy. Projects selected based on their complementarities with other company R&D, and considered important for the company's technological leadership, produced higher impacts. The same was true for project managers who were given adequate time to manage the collaboration and were evaluated based on the results of the project.

> "Ensure that there is a tight link between the current commercial strategy and the research collaboration."
>
> Senior Technology Manager

"I refuse to fund [any collaboration project] if no technical professional inside our company is committed to run the collaboration and bring back information."

Senior Technology Manager

Collaborations should remain aligned throughout the entire project's lifecycle. This is particularly important for projects that required a substantial understanding of company practices. Hence, a best practice is that project managers should continuously check that the university researchers have an excellent understanding of the company's goals for the collaboration.

"You should not underestimate the need to continuously remember the goals of the project to all the participants, especially the students."

Project Manager

"Companies need to be specific on their needs. They must help university researchers to understand the needs of the industry."

Senior Technical Executive

**6. Time Facilitates the Collaboration Process**

The collaboration's duration, and not its budget, has a significant correlation with the project's final outcomes. Over longer periods of time, project managers and university researchers were able to develop a better understanding of the research problem, as well as a common vocabulary in which to communicate the research results.

"Have flexibility in your budget to support a good project that needs to go an extra year."

Senior Technology Manager

## 11. Best practices for managing Industry-University research collaborations

Out of the research findings, we distilled seven best practices project managers can follow while collaborating with universities.

**7 Best Practices**

1. **Select projects that complement R&D taking place within the company.**
   - Align collaborations with company strategy.
   - Leverage existing or potential absorptive capacity.

2. **Select university researchers who understand specific industry goals and practices, or help them gain the knowledge.**
   - Search within your employees' network.
   - Recruit based on previous work or same industry consulting.

3. **Select Project Managers with strong boundary spanning abilities.**
   - Find individuals with diverse personal networks, communication abilities and deep understanding of the collaboration's field.

4. **Promote longer collaboration timeframes.**
   - Make expectations for time scales explicit.
   - Have flexible budgets to extend good projects.

5. **Provide appropriate internal support and accountability for project management.**
   - Allocate sufficient internal funding and time of the project manager.
   - Include project results as a part of the project manager's performance review.

6. **Conduct regular meetings at the company between university and industry researchers.**
   - Make this a requirement.
   - Encourage informal communications which build relationships and trust and increase the knowledge exchange.

7. **Build awareness of the university project inside the company**
   - Promote university researcher interactions with company personnel additional to the program manager.
   - Hold project managers accountable for reaching across company boundaries, even after the project is completed.

## References


Adams, Cristopher P., and Van V. Brantner. "New Drug Development: Estimating entry from human clinical trials." Work Paper, Bureau of Economics, Federal Trade Commission, 2003.

Allen, Thomas J. *Managing the flow of technology.* Cambridge, MA: MIT Press, 1977.

Allen, Thomas J., and Stephen I. Cohen. "Information Flow in Research and Development Laboratories." *Administrative Science Quarterly* 14, no. 1 (March 1969): 12-19.

Ancona, Deborah G., and David F. Caldwell. "Bridging the Boundary: External Activity and Performance in Organizational Teams." *Administrative Science Quarterly* 37, no. 4 (December 1992): 634-665.

Bozeman, Barry. "Technology transfer and public policy: a review of research and theory." *Research Policy*, 2000: 627–655.

Calder, Edward S. "Best Practices for University-Industry Collaboration." S.M. Thesis, Technology and Policy Program, Massachusetts Institute of Technology, Cambridge, MA, 2007.

Chesbrough, Henry. *Open-Innovation.* Boston, MA: Harvard Business School Press, 2003.

Cohen, Wesley M, Richard R Nelson, and John P Walsh. "Link and Impacts: The Influence of Public Research on Industrial R&D." *Management Science* 48, no. 1 (January 2002): 1-23.

Cohen, Wesley M., and Daniel A. Levinthal. "Absorptive Capacity: A New Perspective on Learning and Innovation." *Administrative Science Quarterly* 35 (1990): 128-152.

Cronbach, Lee J. "Coefficient alpha and the internal structure of tests." *Psychometrika* 16, no. 3 (1951): 297-334.

Faulkner, Wendy. "Conceptualizing knowledge used in innovation: a second look at the science-technology distinction and industrial innovation." Chap. 7 in *Managing Knowledge: An*

*Essential Reader*, by Stephen Little, Paul Quintas and Tim Ray. The Open University, 2002.

Food and Drug Administration. *Innovation or Stagnation? Challenge and Opportunity on the Critical Path to New Medical Products.* White Paper, United States Department of Health and Human Services, 2004.

Granovetter, Mark S. "The Strength of Weak Ties." *The American Journal of Sociology* 78, no. 6 (May 1973): 1360-1380.

Hansen, Morten T. "The Search-Transfer Problem: The Role of Weak Ties in Sharing Knowledge across Organization Subunits." *Administrative Science Quarterly* 44 (1999): 82-111.

Katz, Elihu, and Paul F. Lazarzfeld. *Personal Influence: The Part Played by People in the Flow of Mass Communications.* New York: The Free Press, 1964.

Lambert, R. (2003) *Lambert Review of Business-University Collaboration: Final Report*. London: Department of Trade and Industry.

Lee, Yong S. "The Sustainability of University-Industry Research Collaboration: An Empirical Assesment." *Journal of Technology Transfer* 25, no. 2 (June 2000): 111-133.

Maznevski, Martha, and Nicholas Athanassiou. "Bringing the Outside In." In *Knowledge Creation and Management: New Challenges for Managers*, by Kazuo Ichijo and Ikujiro Nonaka, 71-72. New York: Oxford University Press, 2007.

National Science Board. *Science and Engineering Indicators.* Vol. 1. Two volumes vols. Arlington, VA: National Science Foundation, 2008.

Nochur, Kumar S., and Thomas J. Allen. "Do Nominated Boundary Spanners Become Effective Technological Gatekeepers?" *IEEE Transactions on Engineering Management* 39, no. 3 (August 1992).

Nonaka, Ikujiro. "A Dynamic Theory of Organizational Knowledge Creation." *Organization Science* 5, no. 1 (February 1994): 14-37.

Nonaka, Ikujiro, and Hirotaka Takeuchi. *The knowledge-creating company : how Japanese companies create the dynamics of innovation.* New York: Oxford University Press, 1995.

Nonaka, Ikujiro, and Kazuo Ichijo. *Knowledge creation and management : new challenges for managers.* Oxford; New York: Oxford University Press, 2007.

Perkmann, Markus, and Kathryn Walsh. "University–industry relationships and open innovation: Towards a research agenda." *International Journal of Management Reviews* 9, no. 4 (2007): 259–280.

Polanyi, Michael. *The Tacit Dimension.* Garden City, N. Y.: Doubleday, 1966.

Reagans, Ray, and Bill McEvily. "Network Structure and Knowledge Transfer: The Effects of Cohesion and Range." *Administrative Science Quarterly*, no. 48 (2003): 240-267.

Reagans, Ray, and Ezra W. Zuckerman. "Networks, Diversity, and Productivity: The Social Capital of Corporate R&D Teams." *Organization Science* 12, no. 4 (July-August 2001): 502-517.

Schartinger, Doris, Christian Rammer, Manfred M. Fischer, and Josef Fröhlich. "Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants." *Research Policy* 31 (2002): 303–328.

Siegel, Donald S., David A. Waldman, Atwater E. Leanne, and Albert N. Link. "Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies." *Journal of Engineering and Technology Management* 21 (2004): 115-142.

Siegel, Donald S., David Waldman, and Albert Link. "Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study." *Research Policy* 32 (2003): 27-48.

UN Millennium Project. *Innovation: Applying Knowledge in Development.* Task Force on Science, Technology, and Innovation, 2005.

Uzzi, Brian. "Social Structure and Competition in Interfirm Networks: The Paradox of Embeddedness." *Administrative Science Quarterly* 42, no. 1 (Mar 1997): 35-67.

Wilcoxon, Frank. "Individual Comparisons by Ranking Methods." *Biometrics Bulletin* 1, no. 6 (December 1945): 80-83.

# Project Description and Funding

| | |
|---|---|
| D1a. Company Name | |
| D1b. Research Institution Name | |
| D2. Project Name | |
| D3. Interviewee Name | |
| D4. Interviewee Position | Description:____________________________________________________<br>________________________________________________________________<br>Percentage of time you spend on research and research management:__________ |
| D5. Project Description | |
| D6. Project Budget (US Dollars) | ______ Company Investment<br>______ Other Industry Investment<br>______ Government Investment<br>______ University Investment |
| D7. Investment Distribution of Company Contribution | ______ % Central corporate research<br>______ % Business unit/functional department **research** budget(s)<br>______ % Other business unit operating or general budget(s)<br>______ % Other, please specify: ___________________________<br>**100 %** |
| D8. Project Start Date | |
| D9. Project Duration (mo) | |
| D10. Project Initiator- Organization who initiated discussions about the project | _____Company _____Other<br>_____University _____Don't know<br>_____Emerged from earlier joint work |
| D11a. Project Structure | _____Stand alone project<br>_____Multi-project arrangement<br>_____Consortium or other arrangement with multiple sponsors |
| D11b. Previous Relationship | There was a prior relationship with the university research group or unit.<br>____Yes _____No |
| D12. Geography: Distance between university researchers and organization | _____ A short walk (0-15 minutes)<br>_____ A short drive (15 minutes to an hour)<br>_____ A long drive (1-2 hours)<br>_____ A short plane flight (1-2 hours)<br>_____ A long plane flight: (3+ hours) |
| D13. Company Involvement | _____Number of full-time person equivalents inside the company involved in this project |

# Organization and Project Structure

E1. During the project, where were you located in the organization?

____ In a business unit or operating company.

____ In a central research group.

____ Other: ________________________________________________________________

E2. Which of the following best characterizes the focus of the project research?

____Basic research.

____Applied research.

____Advanced development.

E3. Why did your organization decide to do this research outside the company?

| **University researchers…** | Not a Reason | Minor Reason | Major Reason | NA |
|---|---|---|---|---|
| S2a. Are able to do certain things less expensively. | 1 | 2 | 3 | 9 |
| S2b. Bring new and original perspectives to problems | 1 | 2 | 3 | 9 |
| S2c. Add to the company's image of technological leadership. | 1 | 2 | 3 | 9 |
| S2d. Have access to unique facilities. | 1 | 2 | 3 | 9 |
| S2e. Are a valuable source of knowledge about new technologies and applications | 1 | 2 | 3 | 9 |
| S2f. Have critical competencies relevant to the company's business needs. | 1 | 2 | 3 | 9 |
| S2g. Other:__________________________________ | 1 | 2 | 3 | 9 |

E4. How important is the organization's leadership in this area of science & technology?

____ Critically Important- a core capability; science and technology leadership in this area is central to the company's mission.

____ Important- company needs to be internally strong in this area.

____ Somewhat Important- capabilities in this area are available externally, but the company needs some internal strength in this area.

____ Not Very Important- capabilities in this area are readily available outside the company.

E5. Other than time of the project manager, what other resources were contributed to the project?

a. Yes ____ No ____ Company personnel spent time on the project or another project linked to it.

b. Yes ____ No ____ Facilities were made available.

c. Yes ____ No ____ Equipment was made available.

d. Yes ____ No ____ Software was made available.

e. Yes ____ Other. (Specify ________________________________________________)

E9. Were there regularly scheduled face-to-face or telephone meetings with university researchers?

____ No. ____ Yes

E9a. IF YES, roughly how often? Weekly:____ Bi-weekly:____ Monthly:____ Quarterly:____

# Activity Report During the Research Project

**How often** did researchers from the university do each of the following?

(If you feel the activity is Not Applicable to your project, check NAppl.)

| | Never | Once or Twice | Several Times | Many Times | NAppl |
|---|---|---|---|---|---|
| F1. Visited your organization and met the program manager. | ____ | ____ | ____ | ____ | (___) |
| F2. Visited the company and spoke to professionals in a research group about the research. | ____ | ____ | ____ | ____ | (___) |
| F3. Visited the company and discussed applications or other uses with professionals in the business unit. | ____ | ____ | ____ | ____ | (___) |
| F4. Asked questions intended to improve or assure the fit between the project results and the company's needs. | ____ | ____ | ____ | ____ | (___) |
| F5. Helped the company solve an immediate operational problem. | ____ | ____ | ____ | ____ | (___) |

**How often** did **<u>you</u>** do the following during the project?

(If you feel the activity is Not Applicable to your project, check NAppl.)

| | Never | Once or Twice | Several Times | Many Times | NAppl |
|---|---|---|---|---|---|
| F6. Explored connections between this project and other research trends and developments with others in the company concerned with science and technology. | ____ | ____ | ____ | ____ | (___) |
| F7. Met and discussed the project with interested professionals in a business unit or department. | ____ | ____ | ____ | ____ | (___) |
| F8. Solicited suggestions from technical professionals in the company about how the project would better fit their needs. | ____ | ____ | ____ | ____ | (___) |
| F9. Told stories to other company professionals about interesting experiences with methods, lessons or discoveries the project had developed. | ____ | ____ | ____ | ____ | (___) |
| F10. Asked the university researchers for changes of any kind in measurement, procedures or processes to align them with existing company practices. | ____ | ____ | ____ | ____ | (___) |
| F11. Telephoned the university researchers to have unscheduled discussions. | ____ | ____ | ____ | ____ | (___) |
| F12. Brought the project up in conversation with other individuals involved in R&D. | ____ | ____ | ____ | ____ | (___) |
| F13. Used ideas or results from this project in discussions about future technologies the company might consider. | ____ | ____ | ____ | ____ | (___) |

**The following items** refer to <u>your general professional activities</u>.

**Over the last year**, how often did **<u>you</u>** do the following?

(If you feel the activity is Not Applicable to project, check NAppl.)

| | Never | Once or Twice | Several Times | Many Times | NAppl |
|---|---|---|---|---|---|
| F15. Talked with other company researchers about projects **they** were working on within your business unit. | ____ | ____ | ____ | ____ | (___) |
| F16. Attend presentations or had discussions with university researchers **not** directly connected with one of your projects. | ____ | ____ | ____ | ____ | (___) |
| F17. Attended internal lectures or discussed research with Professionals in other business units or functional groups. | ____ | ____ | ____ | ____ | (___) |
| F18. Attended external conferences/seminars or had discussions with researchers outside your company regarding science and technology trends. | ____ | ____ | ____ | ____ | (___) |

CMI© October, 2008

# Project Participants & Communications during Development.

Here are some statements about the people on the project **during the project**. Please circle a number to indicate your level of **agreement or disagreement** with each statement.

| | Strongly disagree | Disagree | Agree | Strongly agree | Don't know/ Not appl. |
|---|---|---|---|---|---|
| T2. You previously had a year or more of experience in a university research laboratory. | 1 | 2 | 3 | 4 | 9 |
| T3. There was a senior manager who supported funding and acted as a champion of the project. | 1 | 2 | 3 | 4 | 9 |
| T4. It was very hard to get university researchers to meet and talk about progress. | 1 | 2 | 3 | 4 | 9 |
| T5. The university researchers had an excellent understanding of the company's goals for the project. | 1 | 2 | 3 | 4 | 9 |
| T6. The university researchers had a high level of technical competence relevant to the project. | 1 | 2 | 3 | 4 | 9 |
| T7. Once the project was well underway, senior university researchers were not attentive to the project. | 1 | 2 | 3 | 4 | 9 |
| T8. You and the research team got along well personally | 1 | 2 | 3 | 4 | 9 |
| T9. Meetings between you and the university researchers were successful in covering the most important issues. | 1 | 2 | 3 | 4 | 9 |
| T10. The researchers were more interested in publishing than the project's agreed upon purpose. | 1 | 2 | 3 | 4 | 9 |
| T11. In general the researchers seemed to feel a strong obligation to meet the company's needs. | 1 | 2 | 3 | 4 | 9 |
| T12. The relationship you had with the university researchers felt like a partnership exploring an area together. | 1 | 2 | 3 | 4 | 9 |
| T13.You had too many other responsibilities to spend as much time as you would have liked on this project. | 1 | 2 | 3 | 4 | 9 |
| T14.This project required a substantial understanding of company practices. | 1 | 2 | 3 | 4 | 9 |
| T15.This project complemented other R&D taking place within the company. | 1 | 2 | 3 | 4 | 9 |
| T16.Key university researchers had previously consulted in the same or a similar industry | 1 | 2 | 3 | 4 | 9 |
| T17.University researchers were good at linking results of their research to industry practices. | 1 | 2 | 3 | 4 | 9 |
| T18. How well this university project performed was/will be part of your performance review, or otherwise affect your career. | 1 | 2 | 3 | 4 | 9 |

# Activity Phasing by Project Stages

**WHEN** did the following activities occur?

W1. How long was the Planning & Selection phase? How long was it from first university-industry discussion of the general idea to the beginning of the actual research? ______ months.

W3. How long did the main research project run? _____ months.

Please check (✓ ) **all stages when the activity occurred.**

(If you feel the activity is Not Applicable to your project, check NAppl.)

| | | Planning & Selection Phase | Main Phase | After Comple-tion | Never | NAppl /DK |
|---|---|---|---|---|---|---|
| W4. | When did university researchers visit the company? | ____ | ____ | ____ | ____ | (___) |
| W5. | When did you or others explain to university researchers how the project fit with the company's strategy? | ____ | ____ | ____ | ____ | (___) |
| W6. | When did university researchers make presentations to interested technical professionals other than you? | ____ | ____ | ____ | ____ | (___) |
| W7. | When did university researchers meet informally with professionals in a business unit? | ____ | ____ | ____ | ____ | (___) |
| W8. | When were there any informal adjustments made to the project's purpose or requirements? | ____ | ____ | ____ | ____ | (___) |
| W12. | When was there trouble communicating ideas and concerns to university researchers because they did not understand industry language? | ____ | ____ | ____ | ____ | (___) |
| W13. | When did it seem that graduate students, technicians or other university staff were not given adequate supervision? | ____ | ____ | ____ | ____ | (___) |
| W14. | When were professionals from other functional areas (marketing, manufacturing, sales, design) brought into meetings with university researchers? | ____ | ____ | ____ | ____ | (___) |
| W15. | When did a group of technical professionals in the company review the project to see if it had implications for other areas? | ____ | ____ | ____ | ____ | (___) |
| W16. | When was there an effort to integrate early findings with other company research? | ____ | ____ | ____ | ____ | (___) |

# Project Outcomes

O1. Did the project accomplish what it set out to do? ____ Yes ____ No

O2. Were there valuable outcomes that were not in the original project plan? ____ Yes ____ No

O3. For each of the following areas, were there any useful outcomes?

"**Useful**" is meant broadly and includes negative findings, for example, information is useful if it finds that a strategy, technology or other possibility is not worth pursuing in the future.

An "**outcome" is a result of the project that creates an opportunity**. In judging whether it was a minor or major outcome, the value of the outcome should be made separately from whether any one then -- or later -- acted upon that result.

"**No outcome of this kind**" includes circumstances where it is not applicable to your project, as well as where it might have been an outcome but was not.

A "**major outcome**" is one that has some kind of clear and significant benefit to the company.

| **Did the project have any useful outcomes in the following areas?** | No outcome of this kind | Minor outcome(s) | Major outcome(s) |
|---|---|---|---|
| a. **Base knowledge.** Produced new ideas to be pursued, better understanding of one or more useful technologies, or other important knowledge to guide future activities. | 1 | 2 | 3 |
| b**. Applied knowledge.** Found a solution to a problem, developed/ used method of analysis, enabled new product or process, or other tangible result. | 1 | 2 | 3 |
| c. **IP**. Created new intellectual property (including software). | 1 | 2 | 3 |
| d. **Human resources**. Called attention to potential hires or useful consultants the company could retain. | 1 | 2 | 3 |
| e. **Relationships**. Developed new and useful relationships between university researchers and the company. | 1 | 2 | 3 |

# Outcome classification

| **O4. How would you classify the research outcomes?** | No outcome of this kind | Minor outcome(s) | Major outcome(s) |
|---|---|---|---|
| a. **Research Findings.** | 1 | 2 | 3 |
| b**. Prototypes.** | 1 | 2 | 3 |
| c. **New Instruments and Techniques**. | 1 | 2 | 3 |

# Action and Project Impact

The following question set comes in two parts.

(1) We first ask whether any one in the company acted in some way to exploit the opportunity offered by the outcomes you just reported. **For each type of outcome, have actions taken advantage of one or more of those outcomes?** (If no result is indicated for an outcome area, Not Applicable is an appropriate response here.)

(2) Please answer the second question for each type of action taken where you answered YES. When the project had a useful result and some action was taken after the project was completed? (If a project is extended with additional funding, the original contract is considered the project, and the continuation and its results are included in the judgment of a project's impact.)

By a "**major impact**," we mean that there is an observable and generally agreed upon positive impact on the company's competitiveness or productivity.

| **(1) Did any one take advantage of any results referred to above?** | **IF YES ➔** | **(2) What has been the level of impact on the company?** | | |
|---|---|---|---|---|
| | | Little to no impact | Substantial Impact | Major impact |
| I1. Did new knowledge influence company decisions or strategy (including research investments)? | ___*Yes* ___ *No* ____ *Not Appl* | 1 | 2 | 3 |
| I2. Was applied knowledge put to use? | ___*Yes* ___ *No* ____ *Not Appl* | 1 | 2 | 3 |
| I3. Were steps taken to obtain, protect or use any intellectual property produced? | ___*Yes* ___ *No* ____ *Not Appl* | 1 | 2 | 3 |
| I4. Were efforts were made to hire or retain individuals that were identified. | ___*Yes* ___ *No* ___ *Not Appl* | 1 | 2 | 3 |
| I5. Have strengthened relationships with university researchers led to engaging them in additional research or other work. | ___*Yes* ___ *No* ___ *Not Appl* | 1 | 2 | 3 |

## Potential Impact

I6. Do you expect this project to have any long-term impact on your company? ____ Yes ____ No

I6a. IF YES: Looking at the long term potential of this project, how much **overall impact** in the long term do you **expect** this project to have on your company?

___Little to no impact

___Substantial Impact

___Major Impact

I6b. If YES: How many years from the time the project was completed will it take for the long term effects of this work to be fully felt? ______ Years.

# Open-Ended Questions

1) Having gone through the survey, do you feel that there is anything that we have left out, which is critical to university-industry collaboration?

______________________________________________
______________________________________________
______________________________________________
______________________________________________

2) If you had to start this project over, what would you do differently?

______________________________________________
______________________________________________
______________________________________________
______________________________________________

3) Based on your experience collaborating with universities, what are the best practices that lead to success?

______________________________________________
______________________________________________
______________________________________________
______________________________________________

4) Was there any central resource/office for industry-university collaborations that helped during the project? How?

______________________________________________
______________________________________________
______________________________________________
______________________________________________

# Senior Technology Manager/Liaison Background Information

| | |
|---|---|
| B1. Company Name | |
| B2. Interviewee Name | |
| B3. Interviewee Position | Description:________________________________________ ____________________________________________________<br><br>Percentage of time you spend on research management:___________ |
| B4. Tenure in This Position | ________ years |
| B5. Total Number of Years in Company | ________years |

# Project Impact

CI1. Please evaluate the following projects based on their overall impact on the company.

By a "**major impact**," we mean that there is an observable and generally agreed upon positive impact on the company's competitiveness or productivity.

| **Project Name and Description** | Little to No Impact | Substantial Impact | Major Impact |
|---|---|---|---|
| CI2a. | 1 | 2 | 3 |
| CI2b. | 1 | 2 | 3 |
| CI2c. | 1 | 2 | 3 |
| CI2d. | 1 | 2 | 3 |
| CI2e. | 1 | 2 | 3 |
| CI2f. | 1 | 2 | 3 |
| CI2g. | 1 | 2 | 3 |
| CI2h. | 1 | 2 | 3 |
| CI2i. | 1 | 2 | 3 |

# Selection Requirements and Expectations

The following table lists selection criteria used by the company for projects, key university researchers and company program managers**.** Please indicate how **your company** views these characteristics by circling the number corresponding to the appropriate categorization. (Check N/A if not applicable)

**Not necessary**: This item is not considered important in university research projects.
**Left to Judgment:** The item depends on the specific project and is left to the discretion of the funding body.
**Expected**: While not required, this item is expected unless there are some special circumstances.
**Required**: This item is required of all university research projects.

| **The project manager …** | Not Necessary | Left to Judgment | Expected | Required | N/A |
|---|---|---|---|---|---|
| M1. Has managed university projects previously. | 1 | 2 | 3 | 4 | 9 |
| M4. Is already highly knowledgeable in the project's research area. | 1 | 2 | 3 | 4 | 9 |

**Key university researchers…**

| | | | | | |
|---|---|---|---|---|---|
| M6. Have an appreciation for company practices. | 1 | 2 | 3 | 4 | 9 |
| M7. Have worked in the research area before and have demonstrated technical skills relevant to the project. | 1 | 2 | 3 | 4 | 9 |
| M8. Have worked in or consulted for industry. | 1 | 2 | 3 | 4 | 9 |

**University projects…**

| | | | | | |
|---|---|---|---|---|---|
| M12. Have a clear link to a company decision or action needed in the next 2 years. | 1 | 2 | 3 | 4 | 9 |
| M13. Are reviewed by a group of technical professionals prior to funding. | 1 | 2 | 3 | 4 | 9 |
| M14. Have a senior manager or senior researcher who acts as product champion (in addition to the person managing the relationship). | 1 | 2 | 3 | 4 | 9 |

# Practice Requirements and Expectations

The following table lists potential practices. Please indicate how your company views each practice by circling the number corresponding to the appropriate categorization. (Check N/A if not applicable)

**Not necessary**: This item is not considered important in university research projects.
**Left to Judgment:** The item depends on the specific project and is left to the discretion of the funding body.
**Expected**: While not required, this item is expected unless there are some special circumstances.
**Required**: This item is required of all university research projects.

| Practice | Not Necessary | Left to Judgment | Expected | Required | N/A |
|---|---|---|---|---|---|
| P1. Regularly scheduled telephone, video or face-to-face meetings between university researchers and project managers. | 1 | 2 | 3 | 4 | 9 |
| P2. University researchers submit periodic progress reports during the project. | 1 | 2 | 3 | 4 | 9 |
| P3. Efforts are made to examine potential impacts on company strategy… | | | | | |
| a. During the project. | 1 | 2 | 3 | 4 | 9 |
| b. After the project. | 1 | 2 | 3 | 4 | 9 |
| P4. The project manager explores potential applications of the research with other interested professionals within the company… | | | | | |
| a. During the project. | 1 | 2 | 3 | 4 | 9 |
| b. After the project. | 1 | 2 | 3 | 4 | 9 |
| P5. Project manager enters important outcomes and other information into company database... | | | | | |
| a. During the project. | 1 | 2 | 3 | 4 | 9 |
| b. After the project. | 1 | 2 | 3 | 4 | 9 |
| P6. After the project is completed, the project manager produces a final report based on a standardized template. | 1 | 2 | 3 | 4 | 9 |
| P7. Professionals from other functional areas (marketing, manufacturing, sales, design) meet with university researchers. | 1 | 2 | 3 | 4 | 9 |

CMI © October, 2008

# Organizational Structure and Decision Making

S1. How important are research collaborations with universities to your organization?
_____Critically important: Central to maintaining the company's competitiveness
_____Important
_____Somewhat important
_____Not very important: We dedicate only a small percentage of resources to university projects

S2. The following items list potential reasons to pursue research projects with universities. Please indicate whether your company engages with universities for any of the following reasons.

| **University researchers…** | Never | Rarely | Sometimes | Frequently | NA |
|---|---|---|---|---|---|
| S2a. Are able to do certain things less expensively. | 1 | 2 | 3 | 4 | 9 |
| S2b. Bring new and original perspectives to problems | 1 | 2 | 3 | 4 | 9 |
| S2c. Add to the company's image of technological eadership. | 1 | 2 | 3 | 4 | 9 |
| S2d. Have access to unique facilities. | 1 | 2 | 3 | 4 | 9 |
| S2e. Are a valuable source of knowledge about new technologies and applications | 1 | 2 | 3 | 4 | 9 |
| S2f. Have critical competencies relevant to the company's business needs. | 1 | 2 | 3 | 4 | 9 |
| S2g. Other:___________________________________ | 1 | 2 | 3 | 4 | 9 |

S4. Please check the item that best describes your company's funding cycle- the timing with which new project proposals are reviewed for funding.
_____ Quarterly _____ Other (Please specify): __________________
_____ Annually ____________________________________
_____ Continuous ____________________________________

S5. Please estimate contract length of the average university funding commitment:
_____ months.

S6. What percentage of original university research contracts (not counting extensions that might be added during a project) are for longer than one year?
_____%

S7. Does the company have a document that describes the formal process for university project approval? ____ Yes ____ No

R1. Does your company have a central resource/office that coordinates all university-industry collaborations?

____ **Yes** ____ **No**

**IF YES,**

| | | | |
|---|---|---|---|
| R2. | Does it have an independent R&D budget? | ____ **Yes** | ____ **No** |
| R4. | Does it help to disseminate the results of completed projects to other parts of the organization? | ____ **Yes** | ____ **No** |
| R5. | Does it play a role in reviewing and evaluating the university research portfolio? | ____ **Yes** | ____ **No** |

# Networks

C1. The following items relate to **networks of professionals interested in research and development** that exist either formally or informally within your company. Please circle the number that corresponds with the degree to which an item characterizes such networks in your company. Also, please evaluate the following items for your company's **networks as a whole**. (Check D/K if you do not know)

**Not at All**: This item does not characterize any of our company's networks.
**Somewhat:** This item is true of some of our company's networks.
**Significantly:** This item characterizes most of our company's networks.

| **Networks** of professionals interested in research and development in our company… | Not at All | Somewhat | Significantly | D/K |
|---|---|---|---|---|
| C1d. Are consulted as a group for advice regarding company strategy. | 1 | 2 | 3 | 9 |
| C1e. Use computer databases to exchange research results and ideas. | 1 | 2 | 3 | 9 |
| C1h. Are periodically reviewed to see how effectively the network is performing. | 1 | 2 | 3 | 9 |

S11. Please describe any keys-to-success for managing and extracting value from collaborations with universities.

S13. Thinking back, is there a university research project whose potential was initially neglected, but later proved to be a major impact for your company? If so, can you please describe the process that allowed you to capture that value