Best Practices for University-Industry Collaboration

by

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Master of Science in Technology and Policy

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Abstract

This thesis reports findings from a study of best practices for university-industry collaboration. The study involved over 70 interviews at 17 large technology companies with company managers and individuals having responsibility for the portfolio of industry sponsored projects at universities. A primary finding concerns the role of boundary agents in a company, i.e. individuals that facilitate knowledge transfer across organizational boundaries. Boundary agents are shown to have a strong positive influence on the value of a project and practices are thus described that foster boundary agent activity. For the cases studied, it is also found that longer term collaborations produce results that have more impact on the company and that geographic separation between university researchers and the company has little affect on project outcomes. Three different types of alignment have been found to affect project results and practices relevant to achieving each type are presented. *External alignment*, the mutual understanding between university researchers and the company of a project’s goals and methods, is achieved primarily through regular meetings and selection of a university researcher with an appropriate background. *Internal exploitative alignment*, in which the impact of the university project is enhanced by complementing research and development within the company, is accomplished through activities such as technical review panels, that explicitly link a project with these internal R&D activities. *Internal exploratory alignment*, the degree to which a project can produce valuable results not in the original research plan, is achieved by actions such as testing the project outcomes on company equipment; these can take place after the main phase of the project is completed.

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1 Project Overview

1.1 Motivation

A number of factors motivate collaboration between university and industry. First, the transition from a labor economy to a knowledge economy implies differences in how firms compete. Staying ahead in a knowledge economy requires new ideas and innovation; universities can be a major resource in this regard. As highlighted in the Porter Report commissioned by the UK government in 2003, companies that attempt to compete on cost only are at a competitive disadvantage (Porter, 2003).

A second factor is the trend toward ‘open-innovation’, the move by companies to engage outside resources as opposed to maintaining all R&D operations in-house (Chesbough, 2003). Advantages for open-innovation include the ability to leverage the best and brightest minds on a truly global scale and the potential for reducing internal operating costs.

Both of these factors were discussed in the Lambert Report of 2004, which explored university-industry collaboration in the UK (Lambert, 2004). The report highlighted the value of working with universities (for example, see Table 1 below) and concluded that for UK companies to maintain their competitiveness they must learn to extract value from universities. It stated that UK universities perform extremely well in basic science and are often at the top of metrics such as articles published in prestigious journals, however, industry has had difficulty extracting value from this research. Specific recommendations were:

- Industry must learn how to extract value from the innovative ideas emerging from universities
- A set of ‘best practices’ for university-industry collaboration should be developed in the area of knowledge transfer and management.

These recommendations are taken as our point of departure.
Enterprises that do not use universities as a partner

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Enterprises that do not use universities as a partner</th>
<th>Enterprises which use universities as a partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased range of goods and services</td>
<td>42%</td>
<td>82%</td>
</tr>
<tr>
<td>Opened new markets or increased market share</td>
<td>40%</td>
<td>81%</td>
</tr>
<tr>
<td>Improved quality of goods and services</td>
<td>46%</td>
<td>85%</td>
</tr>
<tr>
<td>Reduced unit labor costs</td>
<td>33%</td>
<td>65%</td>
</tr>
</tbody>
</table>

Table 1: Benefits to Companies that Collaborate with Universities
Source: Lambert Review (via Community Innovation Survey, (UK), DTI/ONS, 2001.)

1.2 Objectives

The project objectives are:

1) Identify the practices for industrial organizations that support sustainable, high-impact industry-university collaboration.

2) Evaluate and define the underlying rationales for collaboration and the metrics involved in project selection, management, and assessment.

The analysis of university-industry collaboration is based on quantitative data collection accompanied by case studies. The focus is on extracting practices that are effective at engendering high-impact projects, and we have attempted to gather enough variation in both settings and practices to uncover a comprehensive set of best practices. Our goal has been to provide research that is actionable by industry, in other words, to develop a document that applies directly to actions of a project manager and increases the return from his or her interactions with universities. We have worked closely with industry to ensure the findings are presented in a relevant manner.

1.3 Unit of Analysis

Our unit of analysis for this research is single projects, between one university research group and one company. All the participating companies are large, well-established technology enterprises.

Focus on the single project unit of analysis implies that the management practices are less likely to be complicated by consortium, alliance or other organizational dynamics. The results of this
research, which apply to the most basic arrangement, are also applicable in other settings, such as alliances that include single projects, enhancing the utility of the research. Developing and refining our methodology in this ‘simpler’ case can thus be viewed as a prerequisite for transition to other more complex organizational arrangements and levels of analysis (e.g. alliances and SMEs) in future work.

1.4 Project Timeline

Work on the project was started in July 2004. The next year was spent developing an initial survey, conducting a set of case studies at two different companies, and then refining the survey instrument based on this research to ensure it captured all the relevant information. The main thrust of the data collection began in June 2005 and the data now includes over 70 projects at 17 companies. Figure 4 shows the distribution of the projects by industry.

The depth of the data allows us to explore the relationship between practice and performance in university-industry collaborations and thus determine a set of ‘best practices’ for successful collaborations. We can, therefore, also quantitatively address the recommendations of the Lambert Report by helping industry extract value from university-industry collaborations.

Figure 1: Data Distribution by Industry
1.5 Model of the Collaborative Process

The model of university-industry collaboration which we propose is portrayed in Figure 2. The individuals and interactions are based on initial case studies. In this view, university-industry collaborations are broken up into two main stages (project and dissemination), each of which is delimited by three gates, denoted by “selection”, “outcome” and “impact” in the figure.

The chronology implied by the model is as follows. The selection gate marks the choice of project characteristics (type, focus, duration, et cetera) and university researchers (location, background, et cetera). After selection, the ‘project’ stage begins, involving the research interaction, which includes research progress, knowledge exchange and evolution of the relationship. The outcome signals the end of the collaborative research and the incorporation of tangible outputs (e.g. a research paper or software). After the outcome stage, the project enters an internal company dissemination stage in which the project manager, and other company researchers and professionals, disseminate the results of the project and integrate them with products and processes. An impact gate at the right of the diagram then marks the identification of a measurable value to the company. It cannot be emphasized too strongly that there is a difference between outcome and impact; the latter is a direct measure of the success of a project at affecting the company’s competitiveness in an agreed upon and observable way. It is recognized that the impact may not occur until considerably after the project has finished.

We chose to evaluate four primary agents that influence collaborations: university researchers, company project managers, company oversight and standardized practices, and the community of technical professionals. The first two are self-explanatory. The group or individual that represented company oversight varied by organization, ranging from a dedicated director of university research to a chief technical officer. Regardless of the specific manifestation, this individual was responsible for overseeing the portfolio of university projects and influencing management practices and also played an essential role in project selection and dissemination of outcomes. The community of technical professionals represents the network of company employees involved in R&D. We examined the characteristics of these networks such as existence across functional and business units, availability of resources, and importance to the company.
1.6 Assessment Measures

To determine the practices and policies that are most important for making university-industry collaborations valuable, specific outcome and impact measures were constructed. These allow characteristics of the project and actions taken by the company or the project participants to be correlated with the value of a project in different areas: basic research, applied research, intellectual property, human resources, and relationships. To directly capture the important outputs, we asked the project’s manager and another company representative, who had purview over the portfolio of the company’s university projects, to rate each project on a three-point scale (none/little, minor, major). This was done for various types of outputs (e.g. applied research, intellectual property, better relationship). Sections 1.5.1 to 1.5.4 present the assessment measures and findings in more detail.
1.6.1 Outcome vs. Impacts

As mentioned, there is a critical difference between outcome and impact. An outcome is defined as a tangible result of the project, such as a research paper or the identification of a potential employee. An impact is defined as an agreed upon positive influence on the company’s competitiveness or productivity. Impacts corresponding with the above mentioned outcomes would be that the results of the research paper were incorporated into a product or process or that the company actually hired the identified individual. The basic metric is that something changed within the company. Impacts are thus the realization of outcomes in a way that positively affects the company.

Outcomes are more closely linked to the research activities of a project. They are visible, actionable, and provide a tangible goal for the university researchers. However, it is impact that affects company competitiveness. Furthermore, there is not an automatic correlation between outcomes and impact. Table 2 shows that a substantial number of projects examined had major project outcomes as seen by the company, but had little to no impact on the company’s competitiveness. As will be shown, specific company practices can mitigate the gap between outcome and impact.

<table>
<thead>
<tr>
<th>Type of Outcome</th>
<th>% of projects with Major Outcomes that have Little to No Impact on Competitiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic</td>
<td>26%</td>
</tr>
<tr>
<td>Applied</td>
<td>33%</td>
</tr>
<tr>
<td>IP</td>
<td>37%</td>
</tr>
</tbody>
</table>

Table 2: Major Outcomes vs. Impact (70 projects)
1.6.2 Outcome Measures

The five different outcome measures are characterized as:

- **Basic**: New or better understanding of a useful technology.
- **Applied**: Solution to a problem, new method or other tangible results.
- **Intellectual Property**: New intellectual property.
- **Human Resources**: Identification of potentially new employees.
- **Relationships**: Development of new relationships with university researchers.

The outcomes were measured on a three-point scale ranging from ‘no outcome (of this kind)’ to ‘major outcome (of this kind)’ and Figure 3 shows their distribution. The majority of projects examined had some type of success (produced an ‘output’), often in more than one category. However, the quality of that success varied, allowing us to correlate specific practices with project success.

![Figure 3: Outcome Distribution](image)

**Figure 3: Outcome Distribution**
1.6.3 Impact Measures

The five different impact measures are characterized as:

- **Basic**: New knowledge that influences a company decision or strategy.
- **Applied**: Applied outcomes put to use.
- **Intellectual Property**: Steps were taken to obtain, protect or use intellectual property.
- **Human Resources**: Efforts made to hire or retain identified individuals.
- **Relationships**: Strengthened relationships led to future engagement with university researchers.

These items each correspond to the conversion of an outcome into some direct impact on the company. Figure 4 shows the distribution of project impacts. Compared with the outcomes, a smaller percent of projects had a ‘major’ effect on the company as seen by the project manager.

![Figure 4: Impact Distribution](image)
1.6.4 Relationship between Outcomes and Impacts

Tables 3 and 4 present two views of the correlations between outcomes and impacts. Table 3 shows each outcome’s correlation with its corresponding impact on a yes/no variable (‘yes’ it had an impact or ‘no’ it did not have an impact). Table 4 shows the correlations between the level of outcome and the level of impact measured on the same 3-point scale (none/little, minor, major).

As perhaps can be expected, there is a correlation between a project’s level of outcome and whether the project had an impact. Projects with major outcomes were more often identified as having an impact. However, the strength of the correlation is reduced when the level of outcome is correlated with the level of impact, implying that there are other influences on the amount of impact a project has. For example, applied research outcomes correlated with applied impact on the ‘yes/no’ variable \(r=.46, \ p<.01\), but less so with impact on the 3-point scale \(r=.25, \ p<.05\). In addition to outcome/impact correlations between similar categories (i.e. base outcomes with base impacts), there are correlations across categories. For example, base outcomes have a strong correlation with applied impacts \(r=.45, \ p<.01\). This confirms that the outputs of university-industry collaborations are multifaceted, i.e. they are not just basic or applied, but have many components.

The results of Table 3 and Table 4 also indicate that intellectual property impacts are more a function of the project’s outcome \(r=.51, \ p<.01\) and \(r=.52, \ p<.01\) than basic \(r=.23, \ p>.05\) and \(r=.40\) \(p<.01\) and applied impacts \(r=.46, \ p<.01\) and \(r=.25, \ p<.05\). One interpretation is that intellectual property, which is largely explicit, is easier for a company to exploit than, say, basic research results that have a significant tacit component.

The strongest correlation between an outcome and a corresponding impact was ‘human resources’ \(r=.65, \ p<.01\), implying that if a company identifies a strong candidate, they are likely to hire this individual. This quantitatively supports what many project managers indicated during the interviews; working with universities is a way to identify strong researchers and see how they work with company projects. There is also a correlation between enduring relationships and the hiring of students \(r=.33, \ p<.05\). As students are hired into a company they tend to collaborate with their former groups/professors. Although, there is value to this selection method in the existing trust and mutual understanding, our research indicates that this type of selection does not always pair a project with the most appropriate researchers.
<table>
<thead>
<tr>
<th>Outcome (3-point scale)</th>
<th>Impact (yes/no)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>Applied</td>
</tr>
<tr>
<td>Base</td>
<td>--</td>
</tr>
<tr>
<td>Applied</td>
<td>.28*</td>
</tr>
<tr>
<td>IP</td>
<td>.09</td>
</tr>
<tr>
<td>HR</td>
<td>.05</td>
</tr>
<tr>
<td>Relation</td>
<td>.02</td>
</tr>
<tr>
<td>Strategy</td>
<td>.40**</td>
</tr>
<tr>
<td>Applied</td>
<td>.45**</td>
</tr>
<tr>
<td>IP</td>
<td>.07</td>
</tr>
<tr>
<td>HR</td>
<td>.14</td>
</tr>
<tr>
<td>Relation</td>
<td>.09</td>
</tr>
</tbody>
</table>

**Table 3: Outcomes and Impact (yes/no).** The values in the table above are correlation coefficients with their statistical significances given by *p = .05 and **p = .01.

<table>
<thead>
<tr>
<th>Outcome (3-point scale)</th>
<th>Impact (3-point scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>Applied</td>
</tr>
<tr>
<td>Strategy</td>
<td>.23</td>
</tr>
<tr>
<td>Applied</td>
<td>.12</td>
</tr>
<tr>
<td>IP</td>
<td>.12</td>
</tr>
<tr>
<td>HR</td>
<td>.19</td>
</tr>
<tr>
<td>Relation</td>
<td>.01</td>
</tr>
</tbody>
</table>

**Table 4: Outcomes and Impact (3-point scale).** The values in the table above are correlation coefficients with their statistical significances given by *p = .05 and **p = .01.
2 Boundary Agent

Boundary agents are individuals who collect external information and then process and encode that information for use within their local unit (Tushman and Katz, 1980). Boundary agents play a critical role in any organization that relies on the flow of information from one sub-unit to the next or from information brought in from the outside environment. The concept has, thus, had a long history in organizational studies, and many authors have written extensively on this concept and how it relates to communication in organizations (Allen, 1977; Simon 1945; Simon and March, 1958; Tushman and Scanlan, 1981, 1; Tushman and Scanlan, 1981, 2).

Boundary agents are often discussed in the context of organizational communication and information processing (Allen, 1977). One way for organizations to assimilate large amounts of information and make decisions related to that information is to develop specialized units that are capable of processing and acting on different types of information. Often, organizations specialize on the basis of geography, processes, products or services (Simon, 1945). These specialized units are separated from others by the existence of boundaries, not only between other units but also with the external environment.

Within specialized units, local cognitive and semantic structures emerge or are created (Katz and Kahn, 1966). These structures give rise to customized information encoding and processing schemes that are based on the characteristics and the needs of a specific unit. Common factors that influence these knowledge structures are history, values, norms, goals, and requirements (March and Simon, 1958). (See Appendix C for a related discussion of organizational memory) The development of local knowledge structures is highly advantageous because it allows group members to internally communicate information with relatively little error (March and Simon, 1958; Allen, 1977). However, reliance on local knowledge structures causes conflict when units are required to transmit or receive information from other units, either internal or external to the parent organization. Boundary agents, who as individuals able to process information form outside units, translate the information and then utilize and disseminate it within the local unit, are important in mitigating this conflict.

The origins of the boundary agent concept follow from the notion of indirect information flow. Indirect flow is the channeling of information from one source to another via some intermediary. Some of the first work on indirect information flow resulted from studies on voter decisions, which showed that various media sources (newspapers, radio, et cetera) did not affect voters
directly, but rather affected a small group of individuals referred to as “opinion leaders” (Allen, 1977). These opinion leaders then influenced the choices of other potential voters.

More direct origins of the boundary agent concept lie in many works on modern organizational structure, communication and behavior. March and Simon discuss the potential advantages of specialization (March and Simon, 1958). Specialization helps organizational units to focus and hence more efficiently pursue specific tasks. As a consequence, an organization needs to develop channels of communication between units to help resolve dissemination and coordination conflicts (March and Simon, 1958; Simon 1945). While more general than the notion of a boundary agent, the communication channel concept developed by March and Simon serves the same purpose, facilitating information transfer between distinct units. However, there is a substantive difference with later work because of March and Simon’s assumption that boundary spanning via communication channels will take place between two individuals. They argue that these two individuals, one in each unit, will have some common language or scheme that facilitates the information translation and transfer process.

Subsequent research suggested that such communication conduits could actually be single individuals, called technological gatekeepers, who were capable of translating information from external sources and disseminating it within the organization (Allen and Cohen, 1969). By studying two technology development organizations, Allen and Cohen determined that such individuals achieved gatekeeper status by having a superior knowledge of the scientific and technological literatures, in addition to maintaining a greater number of contacts with individuals outside their unit. They also introduced the concepts of internal and external communication stars. Internal communication stars are individuals who are more often approached for technical discussions by their peers. External communication stars are individuals who have a significantly greater number of external contacts. It was found that being an internal communication star is a prerequisite for being a gatekeeper (Allen and Cohen, 1969).

The existence of boundary agents was implied in subsequent work that further developed the concept of gatekeepers (Allen, 1977; Tushman, 1977). However, the preferred term remained gatekeeper rather than boundary agent to avoid confusion with those individuals who only participate in boundary spanning activity. Individuals who simply engage in boundary spanning activity are not automatically guaranteed internal communication star status and by inference gatekeeper status (Tushman and Katz, 1980). An example of someone who is not a gatekeeper
but who engages in substantial amounts of boundary spanning activity is a salesman. Salesmen have the ability to transmit information from the organization to the external environment but they rarely disseminate new ideas and information within the organization. The essential point in being a gatekeeper is the bidirectional nature of the information flow.

Tushman directly introduced the term boundary agent (Tushman and Scanlan 1981, 1; Tushman and Scanlan 1981, 2). Boundary agents were described as executing a two step process; taking new information from external sources, decoding it, and then disseminating the resulting information internally. The difference between boundary agents and those who participate in boundary spanning activity was maintained, again with the distinction lying in the internal communication star status of boundary agents.

To summarize, the concept of a boundary agent has evolved over time. While the concept has its origins in the notion of indirect information flow, the modern conception of boundary agents emerged as a result of organizational specialization and the creation of local knowledge structures. Boundary spanning activity has become an important solution for communication conflicts between differentiated units. The general concept of communication channels led to the definition of gatekeeping individuals; the idea of gatekeepers gave way to boundary agents. Some of the essential characteristics of boundary agents are listed below (Allen, 1977; Tushman and Scanlan, 1981, 1; Tushman and Scanlan, 1981, 2):

- Boundary agents are valuable sources of new information and ideas
- Boundary agents are internal communication stars. Such status is developed through perceived technical experience and expertise
- Boundary agents have substantial external contacts. Such contacts are often established by job transfer or an external outlook.
- Formal status is not a significant predictor of boundary agents
- Boundary agents emerge to bridge specific unit boundaries
2.1 Boundary Agents and University-Industry Collaboration

To address the role boundary agents played in university-industry collaborations, we examined the interactions of project managers with other company professionals and researchers. We measured who they interacted with, what they talked about and how often they interacted. We then constructed a single scale, by summing the six items, to create an overall measure of the degree to which a project manager engaged in boundary agent activity. The items that make up the scale are listed below with question numbers in the survey (See appendix C) and component loadings (i.e. the amount the question contributed to the scale) in parenthesis. The scale had high internal consistency based on the average inter-item correlation (alpha, $\alpha=.816$), implying that the items were all probing the same concept.

- Explored connections between project and research trends (F6, 663)
- Discussed project with other interested professionals (F7, 794)
- Asked others about how the project might better fit their needs (F8, 752)
- Told stories about the project’s findings to other researchers (F9, 647)
- Brought up project in conversation with other R&D individuals (F12, 733)
- Use ideas from the project in discussion about future technologies (F13, 748)

Figure 5: Boundary Agent Activity Practices
2.2 Importance to Project Outcomes and Impacts

The survey results show that the degree to which the project manager engages in boundary agent activity has an influence on both the outcome and impact of a project. This is shown in Table 5, which shows correlations between the boundary agent scale and various output measures. We separately summed the technology outcomes and technology impacts (i.e. basic research, applied research, and intellectual property as opposed to non-technology related outputs such as relationship building and human resources) to create a single outcome variable ('Technology Outcome') and two technology impact variables ('Any Technology Impact' which is a sum of the yes/no measures of impact and 'Level of Technology Impact' which is a sum of the 3-point measure of impact). The table shows that when project managers engage in boundary agent activity, the project was more likely to be successful, especially in producing a long term impact on the company (r=.31, p<.01). As an illustration, when a project manager talks with other researchers and professionals, he gains information that will shape the project results. This could include developing a deeper understanding of other company researcher’s operations and problems, so that the project might be better aligned to their needs (see examples below).

<table>
<thead>
<tr>
<th>Outcome/Impact Type</th>
<th>Boundary Agent Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology Outcome (Sum O1-O3)</td>
<td>.27**</td>
</tr>
<tr>
<td>Any Technology Impact (Sum I1a-3a)</td>
<td>.26 **</td>
</tr>
<tr>
<td>Level of Technology Impact (Sum I1b-I3b)</td>
<td>.18 *</td>
</tr>
<tr>
<td>Long Term Project Impact</td>
<td>.31*</td>
</tr>
</tbody>
</table>

Table 5: Boundary Agent Correlation with Outcomes and Impact

The values in the table are correlation coefficients with statistical significances given by * p=.05 and ** p=.01. The items in parenthesis indicate the questions from the survey that make up the variable (see appendix C).
2.3 Fostering Boundary Agent Activity

There are a number of ways to foster boundary agent activity in company project managers. Making managers aware of the concept and corresponding activities (see Figure 5) through direct training is important; bringing a behavior into conscious awareness is often a powerful driver of change. Kerr and Jackofsky discussed the ability of companies to develop managers for specific purposes and focused on the relative efficacy of training managers versus selecting individuals with certain traits (Kerr, 1989). They found that training is an effective way for organizations to achieve human resource goals, i.e. influence behavior.

Boundary agent activity is dependent on both the individual’s general disposition and the company’s ‘culture’. If project managers are encouraged to be more outward looking this will carry-over into projects. For example, researchers who attended internal lectures and external conferences were more likely to engage in boundary agent activity during the project ($r=.30$, $p<.01$ and $r=.31$, $p<.01$). There are also examples in other contexts. Tushman and Scanlan showed that travel to conferences and professional meetings strengthened a boundary agent’s external communication networks (Tushman, 1977; Tushman and Scanlan 1981, 1).

Example 1: The Project Manager as Boundary Agent

One project we examined involved the development of next generation robotics. The manager was located in a R&D division of the company, which provided the funding for project. The project was classified as basic research and was seen as many years away from producing anything that might tangibly affect a company product. However, the project manager made an extra effort (boundary agent activity is not in a typical job description) to visit and speak with professionals in the manufacturing sector of his company. The discussions produced useful information about how these next generation robotics might be used in practice, turned into tools or integrated into the manufacturing process. The project manager emphasized that these discussions provided invaluable information on the best direction for the project to proceed, a direction he would not have otherwise considered. The outcomes of the project would have been interesting in either case; the researchers were very bright, the area was a ‘hot topic’ and anything the collaboration produced would have been attention-grabbing. However, without the cross-boundary discussion, it is less likely that the project would become part of the manufacturing process with the potential (this has not yet happened) to have a major impact on the company.
Example 2: Encouraging Boundary Agent Activity
The experience of two project managers in one company gives another illustration of the role
of boundary agents. The organization had a research center distinct from the product
development business units. The former conducts work on technologies that are not
necessarily directly tied to company products, while the latter’s work is directly related to
specific products. One manager we interviewed spent many years as a production engineer
performing computational simulation in direct support of product development before
transferring to the research. His background gave him extensive contacts in the business unit
and he often had lunch or met with production engineers to discuss how some of the work he
was doing with universities might help them. The projects he managed tended to have a
tangible impact on the company.

Another project in the research center, however, was managed by a new Ph.D. who, while
completing his degree, had performed interesting and useful analysis for the company. This
individual had come from the outside and had few contacts with product developers who might
utilize the research he was managing. He stated that because he had not spent time outside of
the research center and did not know the product developers personally, it was extremely
difficult to even get them to respond to emails. As a result, sometimes he resorted to having
his summer interns set-up meetings with production people, because the students appeared to
be something of a novelty and were therefore better received. Consequently, the manager had
less information on how his projects might be useful and less opportunity to disseminate the
results.

The two individuals described show how the relationship between new project managers and
the business units can be facilitated. This might be accomplished through required group
meetings or monthly presentations of results and ongoing work. Such facilitation can help new
managers become effective boundary agents.
Another mechanism for fostering boundary agent activity is the degree to which the project is important to the company. If the project is important, project managers are more likely to spend time seeking information for the project and disseminating the results. A number of variables reflecting the importance of the project to the company correlated with boundary agent activity: the project was reviewed by a group of technical professionals ($r = 0.21$, $p < 0.05$), efforts were made to integrate the project results with other company R&D ($r = 0.22$, $p < 0.05$) and the project complemented other R&D ($r = 0.20$, $p < 0.05$). These variables measure how much interest the company had in the project because they either reflect investment of resources (e.g. time of technical professionals on the review panels) or explicit linkages to existing activities. It should be noted that another interpretation of these correlations is that boundary agent activity is the cause of increased importance. For example, boundary agent activity could cause the company to recognize the opportunity to integrate the results with other R&D. Thus, the relationship between boundary agent activity and company importance is likely bidirectional and further research is needed to determine the relative importance of each interpretation. Other variables, which are proxies for importance, that influenced boundary agent activity were the level of company investment ($r = 0.26$, $p < 0.01$) and the project duration ($r = 0.25$, $p < 0.01$). Generally, the amount of money a company invests and how long the project lasts reflect how important the project is to the company’s goals and strategy.

The underlying rationale for the collaboration also influenced boundary agent behavior. Project managers were asked for the primary reason the company chose to collaborate with a university, as opposed to performing the research in house. The choices given were: universities are a source of knowledge about new technologies and applications, universities have original perspectives to problems, universities are able to do things less expensively, universities increase the companies technological image, universities have unique facilities, and universities have critical competencies relevant to business needs.
The first two of these, knowledge about new technologies and original perspectives, were found to have an influence on boundary agent activity ($r=.31, p<.01$ and $r=.24, p<.05$). The third (less expensive) was found to be negatively correlated with boundary agent activity ($r=-.21, p<.05$). Managers are more likely to engage other professionals regarding the project, when working with university researchers is exciting and stimulating, as opposed to, say, trying to do something cheaply.

These practices are summarized in Figure 6.

Figure 6: Practices that Foster Cross-Boundary Agents
3. Other Findings

3.1 The Effects of Duration

The range of project durations surveyed are given in Figure 7.

![Figure 7: Project Durations](image)

Longer duration projects were found more likely to have valuable outcomes and impacts. Specifically, project duration correlated with better 'Technology Outcomes' and more valuable 'Level of Technology Impact' ($r=.36, p<.001$ and $r=.27, p<.01$, see section 2.3 for a discussion of these output measures). Also, longer projects had a greater impact on whether the company hired researchers, including students, who participated in the project ($r=.30, p<.01$). This supports the trend, identified in the Lambert Report, for large companies to pursue longer strategic commitments (Rolls-Royce, GSK, BAE Systems, British Nuclear Fuels are called out in Lambert Report). However, some of the companies we interviewed preferred shorter relationships with a wider range of universities. The difference between companies may emerge from fundamental differences in the perceived utility of university collaboration. In the former case, the companies may primarily see universities as a core component of their research capability, thereby necessitating more stable and predictable relationships. In the latter case, companies that prefer a larger number of distributed, smaller engagements may view universities as a means of keeping current on the latest technologies and trends.
3.2 Geographic Separation

Figure 8 shows the distribution of geographical separation for the projects we examined. University-company separation ranged from a short walk to a long plane flight. Our results indicate that in general geographical separation does not have a major effect on critical issues. More specifically, geography does not directly affect partnership ($r=.02, p > .05$), the university researchers attentiveness to the project ($r=.01, p > .05$), or mutual understanding of goals ($r=-.12, p > .05$). The emergence of email, cell-phones and video-conferencing has made geographical separation for collaboration less of a barrier. In addition to the lack of quantitative evidence indicating a link between geographic separation and outcomes and/or impacts (see Tables 6 and 7), many project managers and portfolio directors confirmed qualitatively that geography was not a concern. However, some individuals indicated that when the separation was such that there was no overlap between the participants’ respective working-days, collaboration was difficult, mostly because one party had to come in at odd hours to attend teleconferences. (One individual stated that he probably would not work with a certain university again because having teleconferences at 2am was very unappealing.)

![Figure 8: Geographic Separation](image.png)
### Table 6: Geographic Separation Affect on Outcomes
Values in the table are correlation coefficients and none were statistically significant.

<table>
<thead>
<tr>
<th>Geographic Separation</th>
<th>Base</th>
<th>Applied</th>
<th>IP</th>
<th>HR</th>
<th>Relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.02</td>
<td>-.03</td>
<td>.05</td>
<td>.13</td>
<td>.05</td>
</tr>
</tbody>
</table>

### Table 7: Geographic Separation Affect on Impact.
Values in the table are correlation coefficients and none were statistically significant.

<table>
<thead>
<tr>
<th>Geographic Separation</th>
<th>Impact (yes/no)</th>
<th>Impact (3-point scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
<td>Applied</td>
</tr>
<tr>
<td></td>
<td>-.18</td>
<td>.15</td>
</tr>
<tr>
<td></td>
<td>.19</td>
<td>-.06</td>
</tr>
</tbody>
</table>
3.3 Internal Alignment

Internal alignment is critical because research that is interesting, well-done and provocative can still prove useless to a company. Unless the goals and methods of a project are aligned with the company’s practices, strategy and needs, the research may not be worth the investment. A major motivation for external collaboration is exploration, leveraging new people with original ideas. However, as qualitatively confirmed during our interviews, giving money to university groups with no real oversight is unlikely to produce results that impacts a company’s competitiveness, implying a minimum amount of alignment is necessary to allow the research to have an impact if results do produce something novel. The challenge for companies is to ensure a sufficient level of alignment without over constraining the project. After two case studies, the findings on internal alignment are presented.

Example 3: The Perils of Internal Misalignment

In a company that designs and manufactures engines, a member of the company’s board of directors, who had been involved with a university engine laboratory, thought it would be useful for the company to have a strong link with the university. Senior management agreed. They initiated a project around an area the university professor, who was an expert in the topic, was interested in, which was of supposed value to the company. The company supported the university researcher for six years and the project produced two MS and one PhD thesis.

The professor thought the project was challenging and the results were useful, but the project had almost no impact on the company. It became clear as the project went on that the topic was not a major problem for the company. The project never had the buy-in from the technical managers at the group level. Without buy-in from technical community, the project was started around a generally interesting problem, but not of immediate concern to the development groups, who had more pressing problems that needed resolution. The misalignment between the company needs and the project’s topic resulted in the outcome (thesis, paper, collaboration between the professor and another university) not leading to a tangible impact.
Example 4: More Perils of Internal Misalignment
A university-industry collaboration was set-up to develop a new manufacturing method for drilling specially shaped holes. The university researchers were given a detailed description of the relevant material and type of hole and were tasked to develop a new approach to complete the task, which would be more efficient than the existing method. The project was challenging, but the university team delivered a proposed approach capable of drilling the required hole. Both the company project manager and the university researchers were pleased with the outcome.

The project manager then went to senior management for approval to incorporate the new approach into the manufacturing process. While senior management was impressed by the project, their view was that it was much too expensive to actually implement. The approach was put on the shelf and it is unclear if it will ever actually be used.

There was internal misalignment because the project manager was unaware of the importance of cost as an implementation constraint that needed to be placed on the university research. The university researchers thus worked at achieving the optimal technical solution when they should have also been concerned with producing an approach that would be within the implementation budget constraints. In hindsight, because the project and company expectations were not synchronized, the project was off the track for valuable impact from the beginning.
3.3.1 Exploitive vs. Exploratory Alignment

There are two dominant reasons for companies to engage universities in collaborative R&D. First, universities are vehicles for exploration, allowing companies to investigate new technologies and stay informed about the latest developments. University researcher knowledge of new technology and their original perspectives were identified as major reasons for collaboration (83% in the case of knowledge of new technology and 88% for new perspectives). Second, 75% of the project managers indicated the research was critical to the company’s business needs, implying that even though there is a strong exploratory component, university collaborations must return exploitable technology or knowledge. Successful projects leveraged both dimensions.

We label **exploitative alignment** as practices that make an explicit attempt to align the project with specific company goals and products. **Exploratory alignment** refers to practices that create new opportunities and connections between the project and other company activities. The challenge for companies is to capitalize on both the exploratory and exploitative aspects of university collaborations. Achieving this balance has been identified as a source of competitive advantage (March, 1991; Benner, 2003; O’Reilly, 2004). Much interest in the balance between exploitation and exploration focuses on the organizational level of analysis, i.e. what organizational forms support different strategies vis-à-vis exploration and exploitation (Gupta, 2006). For example, some authors have suggested that ‘ambidextrous organizations’, which have tightly coupled, yet distinct, exploration and exploitation groups, are effective at achieving this balance (for examples see Gibson, 2004 or O’Reilly, 1996). Others have focused on ‘punctuated organizations’ that cycle between periods of exploration and exploitation (Burgelman, 2002).

In this discussion of exploration and exploitation, we focus on internal activities. Exploration refers to new ideas or technologies, produced by the collaboration, and novel applications within the company that are identified after the project begins. Exploitation refers to the link between the project and other specific R&D activities, made explicit at the beginning of the project.
3.3.2 Exploitative Alignment

We used two variables to measure exploitative alignment, whether the project complemented other company R&D activities and whether the project required understanding company practices. Both of these items were reported by the project manager on a 4-point scale. From the data, we found a number of practices that explicitly aligned projects with company goals and other R&D activities.

We summed two items to create a dummy variable for the degree to which a company made efforts to exploit the research. The first was whether efforts were made by the company to integrate the findings with other company research (W16), and the second was whether the company had technical professionals review the project to see if it had implications for other areas (W15). This dummy variable was correlated with whether the project was exploitatively aligned with the company, especially in the early stages of the project (‘planning’ and ‘set-up’) ($r=.41, p<.01$).

Another factor that influenced whether a project was exploitatively aligned was the degree to which university researchers understood the project’s broader goals, i.e. how the project fit with the company. Our data show the project was more likely to complement other internal R&D if during the early stages of a project prior to starting the main research activities, university researchers met professionals from other business units ($r=.3, p<.05$) and were told how the project fit with the company’s strategy ($r=.33, p<.01$). It is important that this knowledge is transferred to the university researchers early enough so that it can impact their work. A related finding is that university researchers who had previously consulted for industry were capable of producing results that complemented other company R&D ($r=.41, p<.01$). Prior consulting experience gives university researchers the ability to link the project results to industry practices ($r=.33, p<.01$), i.e. the ability to translate and adapt the results to industry practices. Presumably, through working with industry, university researchers develop a better understanding of problems and solutions that are most relevant.
3.3.3 Exploratory Alignment

As mentioned above, a major reason seen by companies for collaborating with universities is the value they bring with regards to exploration, helping the company stay at the forefront of scientific and technological trends. To leverage this capability, the project must be in what we refer to as exploratory alignment. In other words, they must be able to increase the potential that the project will produce valuable outcomes not in the original plan. This includes practices to identify new opportunities that cannot be articulated at the beginning of the project. One such practice is attempting to integrate outcomes after the project is completed. Our data shows that if the company tested results or made efforts to integrate findings with other company research after the main phase, the project was more likely to have valuable outcomes not in the original plan (r=.30, p<.05 and r=.26, p<.05). Also, project managers who explored connections with other company researchers were more likely to produce projects with valuable outcomes not in the original plan (r=.31, p<.01).

Producing valuable outcomes not in the original plan was also a function of the university researcher engagement. University researchers who were more attentive to the project and/or less interested in publishing also tended to produce results that were not in the original plan (r=.27, p<.05 and r=.34, p<.01). Both of these factors, presumably, measure the university researcher’s commitment to producing outcomes that go beyond the contract, outcomes that are not in the original plan.

3.4 External Alignment

External alignment is the project level analogue of internal alignment, measuring how well the university researchers and the project/project manager were aligned. External alignment includes the degree to which the university researchers understood the project goals, had the relevant skills, and were able to shape the research for industry practices and norms.

University researchers and company project managers who interacted often were effective at fostering alignment and mutual understanding of project goals. In particular, the more university researchers had regular meetings with the project manager and visited the company, the more they understood the project’s goals and the more the project had valuable Technology Outcomes (r=.30, p<.01 and r=.21, p<.05).
A number of companies had practices that greatly facilitated interaction. For example, one company gave university researchers company badges so they could easily visit the company. Another company developed a questionnaire that the project manager and the university researchers were required to fill-out together. The questionnaire ensured the project manager and university researchers met face-to-face and asked key questions that when completed together aligned the university researchers and the company.

Two aspects of the university researcher’s background that had a strong influence on alignment and the performance of the collaboration were relevant technical skills and previous experience consulting for industry. University researchers that had highly relevant technical skills were more attentive to the project and had a better understanding of the project’s goals (r=.46, p<.01 and r=.32, p<.01). The relevance of their skills is an indication that they are working in the same area and are thus highly interested in the project area. Moderate amounts of relevance were not enough; it is only when there was a high degree of technical skill relevance that there is good understanding of goals and development of partnerships (96% of the variance in the response to this question, as indicated by the project managers, was in the categories agreed or strongly agreed that university researchers had relevant skills). Company project managers also indicated that they got along personally with university researchers and that the relationship felt more like a partnership when the university researchers had highly relevant skills (r=.31, p<.01 and r=.30, p<.01). Projects that felt like a partnership were more likely to produce new and useful relationships (r=.28, p<.05).

As discussed in section 3.4.2, university researchers with prior consulting experience have a better understanding of the problems and solutions relevant to industry and are therefore, presumably, better able to understand the objectives of the project.
4 Summary of Findings and Future Research

4.1 Findings

The major findings concerning best practices for university-industry collaboration are as follows.

1. Boundary agents, individuals who facilitate knowledge transfer across organizational boundaries, have a positive influence on the value of a project. Our data show that the company’s motivation for starting the project, the importance of the project to the company, and direct training all contribute to the existence of boundary agents.

2. In describing the results of company supported university research, it is useful to distinguish between outcomes, a tangible result of the project, and impacts, an agreed upon positive influence on the company’s competitiveness or productivity. While outcomes are necessary, the company focus must be beyond the outcome and must consider ways in which the research can affect some company product or process.

3. For the companies surveyed, geographic separation between university researchers and the company was found to have no effect on project outcomes or impacts.

4. Longer duration collaborations are found to produce more valuable results.

5. Internal exploitative alignment, the complementarity of a project with other internal research and development activities, increases the likelihood that the project will have an impact on the company. Internal exploitative alignment can be achieved through practices that explicitly integrate the research with other company activities early in the project. One example is technical review panels for project selection. Internal exploitative alignment is also realized when university researchers have a broad understanding of the company’s strategy and other R&D activities, achieved through, for example, bringing university researchers to meetings with professionals from other business units.

6. Internal exploratory alignment, the degree to which a project produced valuable outcomes not in the original research plan, is accomplished by taking actions that identify new opportunities to exploit the research after the main phase of the project is completed, such as testing the project outcomes on company equipment.

7. External alignment, the mutual understanding of a project’s goals and methods between university researchers and the company is important for project success. External alignment is facilitated by collaborations in which university researchers have previously consulted for industry and have regular meetings with the company project manager.
4.2 Future Research

4.2.1 Variable Control

The present study did not examine the influence of different industry, project, or company characteristics. Additional data could control for whether there are best practices for specific industries, for projects with different characteristics (duration, cost, whether the project took place in a central research lab or a business unit, and whether the project was applied or basic research), and company characteristics (experience with university collaboration and the strength of a central oversight office).

4.2.2 Boundary Agent

Several issues relating to boundary agents seem useful to pursue. These are:

a) Modification of the boundary agent concept to include means of communication other than oral.

b) Other factors that influence the amount of technical communication a boundary agent engages in, including company culture and non-technical networks.

c) The evolution of boundary agents over time and the company practices early in a researcher’s career that help develop effective boundary agents.

A significant limitation of this research is the singular focus on oral communication. With the current preponderance of modern communication technologies it can be hypothesized that the increase in reach and hence efficacy of boundary agents has greatly increased. However, as the means of communication become increasingly sophisticated, so does the complexity of communication networks. Therefore, the concept of a boundary-agent may need modification to account for this.

Another limitation stems from the fact that our research only investigated communication star status as a result of an individual’s participation in technical communication, e.g. internal technical lectures. Clearly technical communication is the substantive issue, but there may be other important factors that lead to communication star status beyond simply engaging in technical communication. Social and cultural factors may make certain individuals more inclined or able to communicate with their peers and external sources, and the strength of friendship.
networks might create more opportunities for technical communication. Another possible aspect for investigation, therefore relates to the antecedents of becoming a communications star.

And finally, it would be useful to examine the evolution of boundary agents, i.e. how they develop over time. For example, it would be interesting to be able to determine the factors that early in a researcher’s career lead to more effective boundary agent activity and thus enable the potential for increasing the actual value to the company of the external research that they sponsor.
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References


Appendix A: Communities of Practice

Humans are continuously processing and interpreting external information to learn about their environment. Over the last 50 years many theories of learning have been proposed. These include: behaviorist, learning takes place through behavioral conditioning (e.g. Skinner, 1974); cognitive, learning involves modifying mental states (e.g. Anderson, 1983; Wenger, 1987); constructivist, knowledge is ‘constructed’ by the individual (e.g. Piaget, 1954); social, focusing on knowledge creation as a fundamentally social activity (e.g. Bandura, 1977). However, a significant limitation to all the previous theories of learning, even social, is the restriction of empirical work to ‘classroom’ settings, which lack context (Fox, 2001). Much learning takes place in ‘situated’ environments such as the work place, social gatherings, or more generally, everyday life. In 1991, a new theory of learning was introduced referred to as legitimate peripheral participation (Lave and Wenger, 1991). In their theory, Lave and Wenger tied the learning process to activities and practices that were embedded in communities as opposed to the more rote transfers of information that embody many of the aforementioned ‘classroom’ theories. They introduced the term communities of practice to refer to these situated learning environments.

The concept of a community of practice has become important not only as an intellectual tool for understanding critical aspects of the learning process, but also as a prudent and effective learning process for firms that rely on knowledge for strategic advantage (Brown and Duguid, 1991). This section describes some aspects of communities of practice including concept, genealogy, current trends and relevance to university-industry collaborations.

Communities of Practice Defined

Understanding what the individual words community and practice mean in this context is useful to understanding the concept of communities of practice. We define these two components separately.

Practice

Practice, as described by Lave and Wenger (1991), involves meaningful participation in the interaction among members of a community as they work and learn together. A dynamic and meaningful interaction between the community and its members is at the heart of communities of
practice. Wenger (1998) later refined the concept of practice to include three principal components: negotiation of meaning, participation and reification. Negotiation of meaning arises from the realization that knowledge is not a concrete object, but is ‘negotiated’ as we experience and interact with the world (Wenger, 1998). Knowledge within a community of practice is give-and-take and meaning is constructed by both tacit and explicit interaction between members (Nonaka, 1994).

Participation suggests, as above, action and connection. Wenger describes it as a process that combines “doing, talking, thinking, feeling and belonging” (Wenger, 1998). He notes that participation is not synonymous with collaboration. Participation is a much more inclusive concept and may involve relationships that are conflictual, competitive and political. Participation is also bi-directional because the community influences the participants and the participants influence the community. Participation is membership in a community and becomes part of a participant’s social identity. Individuals who participate in communities of practice at work reshape their social identity (Lave and Wenger, 1991; Brown and Duguid, 1991). This ‘definition’ of participation extends communities of practice to activities that individuals engage in even in isolation. As Wenger (1998) notes:

“Being in a hotel room by yourself preparing a set of slides for a presentation the next morning…is fundamentally social. Not only is the audience there with you as you attempt to make your points understandable to them, but your colleagues are …looking over your shoulder…representing for you your sense of accountability. “

Community

As Wenger (2002) defines it, communities are “A group of people who interact, learn together, build relationships, and in the process develop a sense of belonging and mutual commitment.” A difference between many group level concepts (e.g. teams and work groups) and a community is the existence of a common knowledge structure. This common knowledge structure is engendered by mutual engagement, a common culture, and shared history. Communities are not made by titles and an individual in one company cannot be transplanted into another company and expect to be assimilated immediately into an existing community of practice. He or she will not share the history and culture of the community, and only through engagement will they come
to be accepted (Wenger, 2002). Meeting someone on a plane who grew up in your hometown, went to the same college as you and perhaps even has a similar professional career also does not ensure that the two of you form a community of practice. Mutual engagement is essential for developing trust, respect and a shared identity, all of which are fundamental components of communities.

Communities of practice, as defined, are voluntary arrangements. While it is true that people can be placed in communities, their level of engagement or sense of shared identity is not much influenced by coercion. For a community of practice to be successful as a source of new ideas and learning, members must value the community and feel personally driven to participate in shared activities and learning.

Level of Analysis

Communities of practice have effects at many levels of analysis: individual, group, network, and organization. The one most relevant in the present discussion is the group level. Even though many communities of practice reside in organizations, they are only tangentially influenced by organizational rules and structures; it is likely that many organizations struggle with fostering communities of practice for this very reason. Also, while comprised of individuals, a community of practice cannot be seen as only the sum of its members. Communities of practice are an emergent phenomenon, it is the interaction between members that engenders learning, giving the community its life and value.

Additional motivation for exploring this topic at the group level is that there is currently substantial interest in the research literature and the management community on many group-level topics: high-performance teams, geographically distributed groups, diversity in groups, and group learning to name just a few. The concept of communities of practice has many implications for learning that takes place in these and other types of groups.

Concept Genealogy

Humans have formed communities and learned together for thousands of years. In ancient Greece artisans and craftsmen formed “corporations,” which served both social and business purposes. Socially, corporate members worshipped the same gods and celebrated the same
holidays. Professionally, these same groups shared innovations and trained the next generation of workers (Wenger, 2000). From the middle ages and until quite recently, the concept of an apprentice was similar to a community of practice in that masters, through shared practice, passed trade skills to the young apprentices (Lave and Wenger, 1991).

From dissatisfaction with theories of learning that overemphasized information transfer models, (e.g. classrooms), models of learning that placed knowledge and learning back into a social context developed (Lave and Wenger, 1991; Brown, Collins, and Duguid, 1989). Ethnographic studies of workplace practices also began to reveal a significant disparity between the way companies thought their employees worked (manuals, organization charts, etc) and how workers actually solved problems and accomplished tasks (Brown and Duguid, 1991; Orr, 1990). These studies came to many of the same conclusions that the situated learning researchers arrived at, namely that learning and problem solving emerge through negotiated interactions between people.

Other names also exist for what is essentially the same concept: communities of knowing (Boland, 1995), communities of interaction (Nonaka, 1994), and social capital (Fountain, 1998). This last term, social capital is especially beginning to gain prominence in the literature for describing groups with communities of practice attributes. Social capital extends the notion of communities of practice to include the development of network theory, in addition to extending the concept to other areas of interest, for example political theory (Nahapiet and Ghoshal, 1998; Fountain, 1998a; Fountain, 1998b).

**Implications Management Practice**

The concept of communities of practice has important implications for management practice. The first stems from the failure of information technologies to give the originally envisioned boost (circa 1990) to poor performance and innovation in modern firms. Many firms invested heavily in information technologies on promises of limitless improvements in efficiency, idea dissemination, and innovation, only to realize few or no real gains (Fountain, 1998b). It was realized later that there is a reduction in quality and clarity when tacit knowledge that is present in individuals, groups or organizations is transferred across computer databases and email (Boland, 1995). Therefore, group learning is impacted when they communicate other than through face-to-face interaction.
One example of a group for which the concept of communities of practice has implications is geographically distributed teams. As companies continue to expand and leverage talent globally, groups that are also communities of practice are becoming geographically dispersed. Recently, there has been some important work on geographically dispersed work-groups and teams, but this literature should be extended to include the concept of communities of practice (Cummings, 2004; Kiesler and Cummings, 2002). Groups of individuals that collaborate on specific projects need to learn from one another. In order to be effective at collaboration and joint problem solving, these groups must blend their cognitive maps (also referred in the literature as schemas, knowledge structures, and by various other names- see Walsh (1995) for a general discussion) in order to better understand each other. Cramton (2001) identifies fostering mutual knowledge as the most important antecedent for performance in dispersed groups. In addition, this blending of knowledge structures is necessary for the transfer of tacit knowledge between group members- it is the effective transfer of tacit knowledge that makes collaborations rich and valuable to organizations. Therefore, further understanding how groups learn, develop shared knowledge structures and exchange tacit knowledge via communities of practice and determining how this can be extended virtually is of importance to today’s knowledge intensive companies (Boland, 1995).

Also important for future work is understanding how groups leverage the advantages of communities of practice through an extension of actor-network theories. Actor-network theories suggest that material objects and organizational structures, as well as individuals, can occupy nodes in a network. Some recent studies have posited that this has important ramifications for developing communities of practice (Fox, 2000). For example, in an automotive setting what role does an engine play in a community of practice? Certainly, the engine (or perhaps the design plan of one) embodies years of development, history, practice and company culture- all the things that are essential for a functioning community of practice. This may have important implications because if much of what a group learns is tacitly embedded in its members only, much is lost when the group disbands.
Appendix B: Organizational Memory

Many of the founding works in organizational studies (Simon, 1976; March & Simon, 1958; Cyert & March, 1963), have treated organizations as information processing systems (Galbraith, 1977; Tushman & Nadler, 1978). Work on collective thought by both Durkeim (1895) and Fleck (1938) laid the foundations for this cognitive perspective of organizations. Many authors have posited that organizations are capable of cognition (e.g. Schneider & Angelmar, 1993). Two trends have emerged in the theoretical work on this subject. Some researchers suggest a computer metaphor, while others alternatively focus on social processes as the foundation for organizational cognition (Walsh, 1995). The computer metaphor asserts that organizations store decision information in various structures and processes: culture, transformations, ecology and external archives are a few examples (Walsh, 1995; Walsh & Ungson, 1991). Alternatively, the later treats organizations as interpretive systems (Daft & Weick, 1984). Here the emphasis is on the relationship between social processes and knowledge structures at the organizational level (Walsh, 1995).

While scholars might argue over what metaphor is more or less appropriate and to what degree, most researchers would agree that organizational cognition is a valid construct. Researchers have introduced the concept of organizational memory as a component of organizational cognition. Organizational memory refers to the ability of organizations to encode internally and externally generated information, store that information in a number of different formats and retrieve some manifestation of that information at a later time.

Implicit in much of the relevant research is the assumption that organizational memory is, at least, functionally similar to individual memory; that is organizations have sensors that receive information, a certain capacity to process information via defined symbols and lastly they possess some retrieval capability (Walsh & Ungson, 1991). Many researchers have either directly or tangentially addressed this conceptual extension of memory from the individual to organizational level of analysis: Argyris and Schon (1978) treat it as a metaphor, Sandelands and Stablein (1987) suggest that organizations are indeed mental entities themselves and capable of memory and cognition, Galbraith (1977) argues that while organizations may not necessarily be mental entities they do in fact possess a memory, and lastly various authors have posited that collections of individuals compose organizational memory (Kiesler & Sproull, 1982; O’Reilly, 1983).
All of the above theories are subject to claims of anthropomorphism. There are potentially two common errors resulting from anthropomorphism—errors of commission and errors of omission. Errors of commission occur when irrelevant information is imposed on a target domain. Errors of omission occur when information is transferred without regard for context (Krippendorff, 1975; Walsh & Ungson, 1991). To avoid these common pitfalls, researchers have generally restricted themselves to less stringent functional extensions—focusing on patterns and not dispositional properties (Walsh and Ungson, 1991). For example, organizations have been said to give birth to new firms when they spin off a division, but researchers have avoided talking about the ‘pains of birth.’

Walsh and Ungson (1991) identified three assumptions that underlie theories on organizational memory. The first, briefly discussed above, is that organizational memory functions similar to individual memory. The second, also mentioned above, is that in addition to taking in information, organizations must have interpretive capabilities (Daft & Weick, 1984; Weick, 1979), because they must be able to search and interpret environmental events (Walsh, 1995) and also convert externally generated information to a form that is understandable and contextually relevant to its members. The third assumption concerns the ontological basis of organizations (Walsh and Ungson, 1991). Walsh and Ungson (1991) argue that organizations are a “network of intersubjectively shared meanings that are sustained through the development and use of a common language and everyday social interaction.” Memory is therefore conceptualized as a ‘system of behavior’ (Krippendorff, 1975), as opposed to a variable that produces specific outcomes, and is a product of the complex interactions between individual members and other organizational variables.

Organizations can exist and function outside of any individual member. However, individuals are responsible for the problem solving and decision-making that takes place within organizations. One hypothesis is that organizational memory is little more than an aggregated individual concept. However, interpretations and perspectives differ from individual to individual. It is the shared knowledge structures and interpretation systems that exist between individuals that makes organizational memory a true organizational-level construct (Walsh, 1995). Weick and Gilfillan (1971) have shown that organizations may successfully store and retain historical information regardless of whether or not key organizational members leave.
Therefore, following Walsh and Ungson (1991), organizational memory is defined as a process that includes information acquisition, storage, and retrieval. Before exploring each of these components in detail, it is useful to distinguish organizational memory from decision information. Decision information refers to stimuli that organizational members use to reduce the complexity and equivocality of various alternatives courses of action. On the other hand, organizational memory, as defined above, refers to information that has been stored about a decision stimulus and may or may not be utilized for future decisions. Thus, the substantive difference between the two is the temporal aspect; decision information has a sense of immediacy and it is only when information is actively stored in some repository for later use that it becomes part of an organization’s memory.

Organizational memory consists of three processes: acquisition, storage, and retrieval. These concepts will now be explored in turn.

Acquisition

Organizations rely on information. They constantly search for and process data generated by the outside world, which influences decisions that affect their behavior and performance. This information, both taken in from the outside and generated internally, forms the substance of organizational memory (Walsh, 1991). The quantity and quality of information that an organization stores in its memory is determined by two factors. First, the equivocality of the information influences whether it will be acquired. Here equivocality refers to the information’s ability to be recognized as worth storing by the organization, that it is specific enough for potential usefulness to be perceivable. The second factor critical to acquisition is the idea of an organizationally shared interpretive system. This has been discussed in the literature under various names with differences: schemas (Bartlett, 1932), knowledge structures (Walsh, 1995), organizational frames of reference (Shrivastava & Schneider, 1984), and interpretive schemes (Ranson, Hinings & Greenwood, 1980). These organizational interpretive schemes reduce the perceived equivocality and uncertainty in information. In addition, they provide a common encoding process for all organizational members. In summary, acquisition is the process of taking in decision information and is dependant on the characteristics of the information in addition to the common schemes used by organizations to interpret information.
Retention/Storage

Once information is recognized as valuable and brought into the organization, it must be stored for future retrieval and use. Walsh and Ungson (1991) suggest that information is stored in many locations and structures so that organizational memory is a distributed system. Many authors have posited the existence of various repositories of decision information. For example, it has been suggested that information is stored in physical locations (Simon, 1976), in individuals (Argyris & Schon, 1978), and in accepted procedures (Cyert & March, 1963).

In their comprehensive review of the concept of organizational memory, Walsh and Ungson (1991) summarize five ‘storage bins’ or retention facilities that compose the structure of an organization’s memory. First, individual organizational members store information based on their direct experiences and observations (Argyris & Schon, 1978). Individuals interact with the environment and based on these experiences form memories, belief structures (Walsh, 1988), cause maps (Weick, 1979), values (Beyer, 1981) and various other cognitive structures that reflect and encode what they have acquired. In addition, through the use of files, IT and other memory aids individuals are able to extend their capacity.

Second, organizational culture is able to function as a repository of information. Schein (1984) defined culture as learned way of perceiving, thinking, and feeling about problems that are disseminated throughout an organization. More specifically, culturally stored information is stored in languages (Donellon, 1986), frameworks (Shrivastava & Schneider, 1984), symbols (Pfeffer, 1981) and stories. It should be noted that culturally stored information is particularly vulnerable to being altered or lost during transmission between individuals.

Third, decision information is stored in transformations. Transformations here refer to the process of converting inputs into outputs. Transformations are often embodied in standard operating procedures (Wieck, 1979), routines and procedures (Cyert & March, 1963), and rules (March & Sevon, 1984).

Forth, Walsh and Ungson (1991) suggested that an organization’s structure and work-place ecology are capable of storing information. Organizational structures affect an individual’s behavior and their interaction with the environment. Hence, structure affects what information an individual will be exposed to. Similarly, workplace ecology reflects status and can therefore reinforce behavior and govern what information is available to an individual for acquisition.
The fifth ‘storage bin’ identified by Walsh and Ungson (1991) is external activity. External activity, such as financial records, government reports, industry reviews and the like all contain information that reflects a company’s decision information.

Retrieval
The concept of organizational memory would be irrelevant if there was no way to retrieve information from it. Kahneman (1973) identified two ways individuals are able to retrieve information from organizational memory, automatically and controlled. Automatic retrieval refers to information that is drawn effortlessly and habitually from an organization’s memory (Walsh and Ungson 1991). Rote application of standard operating procedures, heuristics and other means of facilitating information processing without proactive decision processes are examples of automatic retrieval. Controlled retrieval is active and involves conscious search processes. Related to the concept of controlled retrieval are information directories (Anand, Manz & Glick, 1998). Directories, as applied to organizations, are an extension of Wenger’s (1986) concept of group transactive memory. Directories identify not only the existence of some specific information, but also the location and means of retrieving the information. IT databases as well as individuals can serve as directories.

Declarative Memory, Procedural Memory and Innovation
Much of the current research on organizational memory has focused on the distinction between declarative and procedural memory. Declarative memory is composed of general principals and facts that can be applied to a myriad of situations (Cohen, 1991). Declarative memory is useful for making sense of new or novel information and unstructured events. It has been shown that organizations with deep declarative memory are better able to assimilate knowledge that is new or created outside the organization (Cohen & Levinthal, 1990). However, since declarative memory is not comprised of procedures and must be consequently reified for every situation, it slows the decision making process substantially.

Procedural memory contains information on skills, routines and, more generally, how things are done (Cohen & Bacdayan, 1994). It is automatic and largely inarticulate- thereby containing much of an organization’s tacit knowledge (Cohen, 1991; Nonaka, 1990). Procedural memory has the advantage that it will produce solutions to problems rapidly and coherently (Moorman & Miner, 1998). But, concomitantly, rote application of procedural memory leads to inappropriate
application of organizational routines with deleterious consequences for organizational performance.

Organizational Decision Making and Innovation

There is an ongoing debate concerning whether managers should make choices based on decision information stored in organizational memory. On one side of the debate, people argue that overly relying on information stored in organizational memory can blind decision makers to aspects of the environment and internal signals that lay outside established knowledge structures. An illustrative example of this is provided by Weick (1979). Weick relates the ebullient mood of the German general Albert Speer when during WWII Allied bombing destroyed a large cache of Nazi files and planning documents. The reason for Speer’s mood was that he could now create new and more effective plans instead of being constrained by the existing and antiquated bureaucratic procedures that the Allies just destroyed. Of course, if organizations ignore their history and lessons learned entirely, they are setting themselves up to repeat past mistakes. In addition, standard operating procedures and other routines that compose parts of an organization’s memory provide efficient and economic transactions by reducing search and decision costs. Lastly, declarative memory can facilitate problem definition, alternative solutions and aide with the decision process itself (Walsh and Ungson, 1991). Therefore, there exists some optimal balance between using memory as a guide, but not overly relying on it for decisions.

For a more specific instance of memory’s impact on a decision process, consider the case of innovation. Following the arguments above, reliance on procedural memory will allow a firm to repeatedly and efficiently produce coherent incremental innovations. However, over reliance on procedural memory will impede more disruptive forms of innovation, for example architectural and radical (Henderson & Clark, 1990). In contrast, strong declarative memory, which functions well in novel situations, should allow organizations to successfully realize radical innovations while paying a price in processing speed. The implications for management are that there exists some optimal balance for using procedural and declarative memory that will allow for the most efficient realization of innovation while not overly proscribing the scope of that innovation. Interestingly, Mooreman and Miner (1998) suggest that repeatedly engaging in radical innovation may allow for the development of a radical innovation ‘meta-routine’. Over time, such a meta-routine would become embedded in an organization’s procedural memory, and thereby achieving radical innovation would become institutionalized. More research is needed on these areas of organizational memory to further explore the implications for decision making and innovation.