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EXTERNAL SOURCING OF CORE TECHNOLOGIES AND THE ARCHITECTURAL DEPENDENCY OF TEAMS

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ABSTRACT

How do teams complete a task involving critical knowledge that is both complex and external to the team itself? This is a task characterized by a particularly difficult tradeoff between external search for important knowledge on one hand and internal coordination on the other. I explore the question in an inductive study of new product development teams in the pharmaceutical industry. Specifically, I investigate different approaches to managing the important task of core technology sourcing (the identification, evaluation and integration of an external technology that constitutes a core subsystem of the product). This research resulted in two key findings. First, in contrast to previous research suggesting that high-performing teams do not engage in any significant external search for complex knowledge, or that such search should be limited to the early stage of a team's work, the study finds that a positive team outcome is associated with continuous deployment of many search modalities of different kinds. By coupling this search behavior with intensive communication and flexible decision-making, internal coordination problems are offset and the benefits of external search are leveraged. Second, this research shows that search behavior is significantly dependent on factors external to the team. Specifically, search behavior is enabled by factors in the task environment, such as how structures and processes are designed at the organizational level, and by the knowledge handed down by previous teams.

I develop the concept of "architectural dependency" to capture how the behavior of core technology sourcing teams is dependent on factors configured across three fundamental dimensions (the team, the task environment, the behavior of previous teams), and importantly, the way that they are linked together. These architectures of factors are molded only slowly over time, and I found this change to be driven by the overarching organizational regime adopted at the organizational level. I conclude by discussing conditions under which architectural dependency may be useful as an interpretive key to team behavior in settings other than core technology sourcing.

“The very tough challenge we face as a team is that all that really technical knowledge we need to do this right is out there, not in here.”

- *Team Leader*
Pharmaceutical Licensing Operations

This article is about how teams manage a task when the knowledge needed for task completion is highly *complex* and resides *outside* the boundaries of the team. It is based on an investigation of how new product development teams identify, evaluate and integrate an external technology that constitutes a core subsystem of the product. This task, “core technology sourcing,” is different from conventional outsourcing since the sourced technology constitutes the heart of the product around which other components and subsystems configure (Tushman and Murmann, 1998). Importantly, this task presents teams with a particularly difficult knowledge-coordination tradeoff. On one hand, the highly complex knowledge forms a force for *narrowing* external search since it threatens to disrupt well-coordinated internal team processes. On the other hand, the highly external nature of knowledge is a force for *broadening* search activities since the lack of search threatens to starve the team of essential knowledge.

When task completion is dependent on knowledge residing outside the team, the external context moves into focus. The role of context and external activities has lately come to the forefront of interest among students of team behavior. Traditionally, models of team effectiveness have focused on how internal processes convert inputs into outcomes (Goodman et al. 1987; Cohen and Bailey, 1997). True to their origins in a closed laboratory setting, these input-process-output models rarely put contextual variables in the foreground. In a real-world setting, however, a team’s strategies for managing external constituents can explain a significant portion of the variance in team outcomes. This fact was shown early on by those studying innovation and captured in such concepts as “technological gatekeeping” (Allen, 1977) and “boundary spanning” (Tushman, 1977). More recently, those focusing on the team as the unit of analysis have started to explore the implications of context for effective team behavior (Ancona, 1990; Ancona and Caldwell, 1992a; Austin, 1998).

A central issue in the interaction between teams and their context is how to balance the need for external knowledge on one hand and the need for a smooth internal team process on the other. Interest in this “knowledge-coordination tradeoff” has a long tradition among students of innovation (Hagstrom, 1965; Allen and Cohen, 1969). It is particularly salient in a setting in which knowledge critical to task completion is highly complex, notably product development in high-tech industries (Roberts, 1981), since this makes the search for and transfer of knowledge across team boundaries highly problematic (Hansen,

1999). The crux of the matter is that teams working with complex knowledge, which is characterized by high interdependence with an extensive pool of competencies (Teece, 1986; Winter, 1987), typically need external knowledge to complete their task and therefore they need to engage in external search activities. However, external search is often detrimental to a smooth team process, which is key to effective implementation.

Discussion of the knowledge-coordination tradeoff among team scholars is largely rooted in the discourse on demography. As a consequence, rather than looking at the knowledge flows directly, this literature is based on the assumption that high team diversity leads to a broader flow of knowledge into the team. Those who have focused on the coordination problem usually point to the need for similarity among team members to ensure a smooth process (Pfeffer, 1983; O'Reilly, III et al. 1989), whereas those who focus on the knowledge benefits point to the need for dissimilarity among members to ensure that non-redundant and varied information is brought into the team (Ancona and Caldwell, 1992b). As pointed out by Reagans and Zuckerman (2001), the debate has a parallel in the literature on social networks and social capital. One perspective stresses the benefits of “closure” (Coleman, 1988), i.e. when relations form a dense web of connections (cf. Granovetter’s notion of “strong-ties” 1973). Such closure is argued to enhance cohesion (Portes and Sensenbrenner, 1993) and trust (Coleman, 1988). Another perspective, represented by Burt (1982; 1992), stresses the value of not having closure in a social network since it ensures better access to information (cf. Granovetter’s “weak-ties”, 1973).

Empirical investigations of the knowledge-coordination tradeoff have produced mixed results. Some studies have found the benefits of external knowledge to outweigh the cost, and others have found the opposite. However, few studies have looked directly at the flows of knowledge and how teams actually manage the knowledge-coordination tradeoff. There are two significant exceptions which address one or both of these issues. The first, rooted in the team literature, is Ancona and Caldwell’s (1992a) study of 83 product development teams in five high-technology companies. The study found that successful teams limited external search activities to early stages of the process and, thus, largely avoided the detrimental effects to implementation. The second, rooted in the social networks tradition, is Hansen’s (1999) study of 120 product development teams in one high-technology firm, which found that successful teams did not make extra-organizational search efforts for complex knowledge a significant part of the process at all. In both of these studies, the teams worked with products whose core technology was developed internally. Importantly, the knowledge-base upon which a core technology rests is typically complex and has often evolved over a long period of time (Kogut and Zander, 1992; Leonard-Barton, 1992). Furthermore, when the core technology has been developed internally, the supporting knowledge-

base is largely found within the team's own organizational unit. For example, a team developing a new car model based on an engine designed in-house has easy internal access to its entire history from early experiments to final trials. When this is the case, one might expect the team to successfully limit external search activities to an early stage, or even to discard external search altogether. If the core technology is not developed internally, however, it is not clear that these courses of action are an option since the knowledge support needed largely resides outside the team's organization.

This study extends our understanding about how teams manage the knowledge-coordination tradeoff by focusing on a task, i.e. core technology sourcing, that is dependent on complex knowledge outside the boundaries of the team's organizational unit. This activity provides an excellent arena to explore the knowledge-coordination tradeoff since the tension between the need for external complex knowledge and the need for internal coordination is particularly salient in this task.

Core technology sourcing is becoming increasingly important, particularly in innovation-based industries. As technologies become more complex, the knowledge needed to support a stream of successful products is increasingly difficult to nurture within the boundaries of one product unit. In addition, core technology sourcing is an important strategy for managing technological discontinuities (Anderson and Tushman, 1990; Leonard-Barton, 1992; Stuart and Podolny, 1996). Computer hardware manufacturers, for example, are turning to software developers who are working with Internet portal firms that are teaming up with telecom companies, and so on. A common thread is the wish to improve one's own products and capabilities by drawing upon the technologies of someone else. The effect of this trend can be witnessed in a mosaic of joint-development and technology acquisition projects in a wide array of high-tech industries (Coombs, 1998). If mastered, the rewards of core technology sourcing can be great. Consider the stellar performance of Nokia, which evolved from a firm whose main business was rubber boots to overtake archrivals Motorola and Ericsson, the inventors of most standards in the handheld phone industry. Nokia's phenomenal success is widely attributed to the capability of its product development teams to source leading edge external technologies in areas as diverse as radio systems and consumer product design (Birkinshaw and Hagstrom, 2000).

The data in this paper are drawn from an in-depth study of pharmaceutical in-licensing teams. In the wake of the molecular biology revolution and rapid industry consolidation, the practice of developing drugs based on molecules acquired from outside sources (in-licensing) has become a key element of competitive success in the pharmaceuticals business. Hence, the management of in-licensing teams has emerged as a strategically critical issue in the industry. The first important finding of the study is that

rather than avoiding external search activities or limiting search to certain stages of the process, successful teams continuously deploy many search modalities of different kinds throughout the process, thus addressing the team's need for external knowledge. The type of search changes over time, but in contrast to what previous studies of product development teams have found, the amount of search remains large. Furthermore, they couple this extensive search with intense communication and flexible decision-making, which address their need for internal coordination and leverages the benefits of external search.

Given that the studied teams were deliberately chosen because of their extreme dependence on external knowledge, it was not unexpected to find a search pattern that differed from previous studies of product development teams. What was not expected was the very strong dependence of team search behavior on factors outside the team. Specifically, the second important finding is that team search and coordination is enabled and constrained in important ways by factors in the task environment, such as how structures and processes are designed at the organizational level, and by the knowledge handed down to them by previous teams. Importantly, the study suggests that factors in these three dimensions (team, task environment, behavior of previous teams) are tightly intertwined forming an architecture upon which the team is fundamentally dependent. I develop the concept of “architectural dependency” to capture this insight. The term is inspired by the work on “architectural innovation” by Henderson and Clark (Henderson and Clark, 1990) who made the point that in trying to understand the dynamics of innovation, the way in which technological components are linked are at times more important than the components themselves. Analogously, the way factors inside the team, outside the team and in the behavior of previous teams are linked across levels can be crucial in trying to understand the dynamics of team behavior. These architectures of interdependent factors cannot be changed in an instant, but rather, they are systems that change only slowly over time. Importantly, I found that the architecture upon which teams are dependent is driven over time by the regime adopted at the organizational unit level. In this study, some teams benefited from a regime of integration with external constituents prioritizing the need for external knowledge. Under this regime an architecture evolved that enabled every new team to perform better than the previous one. Other teams, by contrast, were hampered by a regime of integration with internal constituents prioritizing the need for internal organizational coordination. As a consequence, these teams could not adopt productive search behavior even when they saw the need to do so. An important contribution of this paper, then, is to demonstrate how findings resulting from research focused on team level factors may be significant but yet incomplete. By systematically investigating how team behavior and the underlying contextual forces that enable and constrain team action are linked, this research suggests that we can be more precise in our understanding of why teams behave the way they do.

METHODS

Research Design

Due to the lack of previous research on core technology sourcing, the focal phenomenon does not lend itself to deduction of hypotheses from existing literature. Instead, I used an inductive multiple-case research design. This enabled a replication logic in which the cases are treated as a series of independent experiments (Yin, 1989). Multiple cases also augment external validity. While I did spend some time before I started my fieldwork thinking about concepts that might be of interest to investigate, e.g. interactions between teams and their external context, I had begun with no hypotheses or reliable measures in hand. They emerged during the course of the research.

The research presented here is the result of a two-year study of Pharma Corporation, one of the world's largest pharmaceutical companies.¹ Being a product of two successive and recent mergers, Pharma was particularly suitable for my purposes since the setting provided an opportunity for in-depth research in an environment with three distinctly different kinds of management. Furthermore, with a rapidly changing competitive and technological landscape and with critical expertise increasingly spanning the boundaries of firms, the pharmaceutical industry is an ideal setting for the study of core technology sourcing. The choice of core technology sourcing in drug development, or "in-licensing" as it is often called in the pharmaceutical industry, as the focal activity came up in joint discussions with the firm. It was a suitable choice for a number of reasons. First, it was a well-defined team level activity with a clear objective. Second, it was a process that spanned a relatively short time in an industry with famously time consuming R&D processes. Third, in-licensing had recently been dubbed a strategic priority by Pharma's new CEO.

Certain steps always form part of the in-licensing process: (1) identification of the molecule; (2) pre-screening of the molecule using publicly available information; (3) complete research on the molecule starting with the obtainment of confidential information and involving a thorough analysis of technical, commercial, organizational and strategic aspects of the technology; and (4) capture, which involves the pursuit of a final agreement with the licensor. This phase frequently overlaps with the research phase, and the objective is to capture maximum value, which may involve acquisition as well as the decision to discontinue the process. Furthermore, certain functions are typically involved in any in-

¹ Pharma Corporation is a fictitious name.

licensing team, e.g. clinical development, project management, and business development. The in-licensing process as well as the functions are illustrated and described in Figure 1.

Insert Figure 1 about here

Data Collection

Interviews. The primary source of data was semi-structured interviews with individual respondents. Altogether, I conducted 92 interviews, a majority of which were taped. Interviews lasted between 30 minutes and three hours, but typically 90 minutes. The first couple of interviews may be characterized as familiarization interviews.² Mainly conducted with top management, these interviews' main purposes were to gain mutual trust and understanding of our respective objectives as well as to establish an infrastructure for the research project. Some main features of the latter were a confidentiality agreement, a sponsoring letter from top management explaining the importance of my research at Pharma, my own corporate telephone number, and an R&D director who became my internal research associate with time allocated to work with me. Having selected cases (see below for details), I conducted project specific interviews to build case histories. I also interviewed the top manager that was ultimately in charge of any given project. Due to the high level of detail desired, I did two to three follow-up interviews for each case and had interviewees review case descriptions and add some details. In addition, I interviewed one to three individuals from the licensor that had worked on the project. At a later stage, I interviewed people involved in ongoing projects. This enabled me to track causal relationships in the in-licensing process, which enhanced the internal validity of the study (Leonard-Barton, 1990). Three interview guides were used to aid the interview process. These were tailored to top management, project team members, and licensor personnel respectively.

Questionnaires, observation and secondary sources. I used a questionnaire with the main purpose of assessing outcome (measures are described in detail below). To complement my understanding of the phenomenon, I also engaged in real-time observation. Specifically, I attended management meetings, project team meetings, presentations by management consultants, conferences and workshops. Furthermore, I had access to secondary sources from Pharma such as internal newsletters, project reports,

² The familiarization interviews counted for six of the total of 92 interviews. These interviews were complemented by numerous short phone conversations and emails to get the practicalities of the project in place.

email correspondence, strategy documents, and process manuals. Finally, at the end of each day on site I wrote field notes with general observations.

Case selection. I selected the case studies according to the following steps. First, together with the internal research associate I worked out a list of criteria for case selection. Important criteria for Pharma were that the projects had taken place within the last two years, that they had been of strategic importance, and that they had passed through all the phases of the in-licensing process.³ In order to exclude factors unrelated to the research question, I added the criteria that the sample should be equally distributed across the three sites— referred to here as Alpha, Beta, and Gamma—at which in-licensing projects had been managed, that samples of projects *within* sites should be in the same therapeutic area, that samples of projects *across* sites should be in therapeutic areas that are highly comparable in terms of the kinds of processes and technologies involved, and that all the sampled projects involved molecules that had reached at least Phase II development. Second, a letter signed by the corporate R&D president was sent out to the three sites requesting that projects for the study be suggested. Third, the internal research associate and myself reviewed the received suggestions. After discussions with the R&D president and the vice president of R&D strategy a list of 12 projects to study was drafted, nine of which turned out to fit the selection criteria. I studied all these projects in-depth, but as it turned out that the project stories at Gamma contained a number of extraneous factors influencing the course of events I will exclude them from the following analysis.⁴ Project descriptions of the remaining six cases, including the data collected for each, are listed in Table 1 below.

Insert Table 1 about here

Data Analysis and Measures

At the outset of the study, I had a notion of some concepts that I thought might be of interest, but not what the specific constructs or relationships between them were. As is typical of such exploratory research, I started out by building individual case histories with the view to leave further analysis until all cases were completed. This way the independence of the replication logic was maintained (Yin, 1989).

³ This might sound as a case of sampling on the dependent variable. However, the advancement through phases is not equated with success. In fact, the early termination of a project is often regarded as a great success.

⁴ The projects were not in the same therapeutic area, Pharma's CEO was personally involved in one of the projects, the first priority at the unit during the relevant period was post-merger integration, and input from licensor personnel was not obtained from any of the projects.

Once the case stories were written up, I checked with a number of informants for each project that the stories I had crafted corresponded with facts. As a further check on the stories, two researchers with no prior exposure to the research were asked to read the original interviews to form independent views. Once differences were reconciled, I revisited the case stories to identify similarities and differences across cases. For each emerging insight I revisited the original field notes, interview notes and tapes to further refine my understanding of events. I also created tables and graphs to facilitate cross-case comparisons.

When working with interviewees' recollection of historical data, retrospective bias is an issue. First, there is a risk that team members reconstruct their perceptions of the process after it is completed based on the team's performance. Recent research in psychology has contributed to reducing the concern about this so-called "halo effect" (Balzer and Sulsky, 1992; Murphy et al. 1993). Nevertheless, if there is agreement among team members that a given project was a failure, it is reasonable to argue that there is a risk that the retrospective account of how the project unfolded will be colored by this view. This kind of bias was partly mitigated by the fact that important process factors were largely factual, not attitudinal (e.g. amount of search). The risk of halo effects was further reduced since none of the drugs had reached the market at the time the assessments of process and performance were made. For example, one of the cases eventually resulted in Pharma's best selling drug, but this was not known at the time. Second, there is a risk that team members simply fail to remember important events of the process. The use of multiple sources, notably numerous secondary sources, and the detailed data obtained partly managed the risk of such re-call bias. Furthermore, there are no reasons to believe that potential re-call bias in the studied setting would be non-random, and hence, a source of systematic distortion.

At this juncture, it is helpful to preview some of the central concepts of the coming sections. One such concept that emerged as very important was external search. After consulting with a number of people with project experience at Pharma to assure face validity, the following simple definition was agreed upon: "to go outside the team to search for knowledge and information important to the task". I asked team members about the number as well as the kind of external search initiatives taken. This resulted in five sources of external knowledge related to two kinds of knowledge. The sources were (1) experts inside Pharma who were not members of the team (internal expertise); (2) experts outside Pharma (external expertise); (3) databases (free or paid for subscriptions); (4) reports from previous projects; and, (5) the licensor. The kinds of knowledge were technical knowledge related to the molecule itself and process knowledge related to the in-licensing process, e.g. how to manage the relationship with the licensor. I asked team members to distinguish between successful and unsuccessful search. However, no meaningful distinction between the two could be established. An important reason for this was that while

the degree of usefulness of the knowledge produced by different search initiatives varied, team members found that search invariably produced knowledge that was useful to some extent.

Another concept that emerged as being of great consequence was mechanisms for internal coordination. Two coordination mechanisms stood out in this setting. First, internal communication, which assured that important knowledge was discussed and spread in the team. An easily quantifiable measure of this concept was the integrative meeting, in which members met to share and discuss knowledge. Second, decision-making flexibility, which made sure that the team process adapted to new knowledge and information. A useful proxy of this concept was what team members referred to as “just-in-time” decisions, which were reactive decisions prompted by new and unexpected developments.

I developed the team performance measure in the following manner. In the absence of objective performance measures, such as product sales, I started out with a subjective measure that has previously been used with success by other scholars (Hauptman 1986; Ancona and Caldwell 1992). Using 5-point Likert scales, this measure asks respondents to rate each team’s efficiency, technical quality, adherence to schedules, and adherence to budgets. After piloting my questionnaire, I significantly altered the questions according to suggestions from respondents. Specifically, the questions related to adherence to budget and schedules were dropped since they were only vaguely related to the way in which the respondents judged team performance. Instead, the questions related to efficiency and technical quality were kept and expanded into three dimensions: scientific and technical aspects, financial and commercial aspects, and overall. I then asked three people within Pharma who were not members of the team, a number considered both sufficient and cost-efficient (Libby and Blashfield 1978), to rate each team: the senior executive in charge of the product development function at the time of the project and two members of the high level committee that reviewed the progress of the project. Analysis yielded one single variable with satisfactory validity, internal consistency reliability and inter-rater reliability.⁵

⁵ Although the sample size was small, the performance items were subjected to a principal components analysis to identify underlying patterns. The analysis yielded a single factor. Inter-item correlations ranged from .7 to .96 and internal consistency reliability (Cronbach’s alpha) of the single scale was very high (.97). Finally, data gathered from individual respondents to assess a group-level variable must converge so that the intraclass correlation is greater than zero (cf. Edmondson, 1999). To generate the intraclass correlation coefficient, one-way ANOVA was conducted with team membership as the independent variable and the team performance scale as the dependent variable. The intraclass correlation coefficient for the performance variable, measuring the extent to which team members’ responses agree with each other and differ from other teams, was significant at the $p < .00001$ level.

TEAM EFFECTIVENESS

Table 2 presents a ranking of the teams studied according to effectiveness. The differences in how the teams performed are quite striking. In particular, AlphaTwo and AlphaThree distinguish themselves as high performers. AlphaOne is ranked ahead of all the Beta projects and thus secures all the top three spots for the Alpha site. The difference between AlphaOne and BetaTwo is rather small, however, which reinforces an impression of a sample with two high performers and four low performers.

Insert Table 2 about here

In the following sections I will identify and discuss how a set of distinct factors and behaviors help explain why the Alpha teams fared better than the Beta teams, but also why AlphaTwo and AlphaThree performed better than AlphaOne. Some of the factors that I found to be important are new, but others have well-established antecedents. Importantly, the main thrust of this paper is not to identify an range of new components of an effective team process, but rather to show how factors and behaviors form a coherent whole, an internally consistent architecture of mutually reinforcing components, across levels to create a team outcome in the studied context. Before describing the findings in detail, however, I will tell the story of two very different ways of managing pharmaceutical in-licensing.

A TALE OF TWO TEAMS

The rich data provided detailed accounts of the histories of the studied projects. Some stories told of great successes and others of failures, some told of teams disrupted by problems and others of teams that somehow dealt with adversity successfully. The insights presented in this article flow from these rich data. Before turning to those insights, I will describe some of the important data that led to them. While the data on team outcomes suggest a configuration of two high performers and four low performers, the descriptive data implies a different clustering of the teams. Specifically, team characteristics vary substantially across the studied sites, but are very similar within those sites. I describe one project from each site in detail here that together represents many of the observed differences. Table 3 complements the stories by demonstrating the similarity of project characteristics within each site.

Insert Table 3 about here

The Case of AlphaTwo

The AlphaTwo story is one of success. The molecule in focus belonged to a class of compounds used to treat inflammation, and the licensor was a mid-sized biotech firm. AlphaTwo was the second in-licensing project at Alpha involving a molecule of this therapeutic class.

Identification. With the strategic plan as a basis, a global search for inflammation molecules was launched. A business development manager headed the team with two subordinates by his side, and he became the project manager. Representatives from pre-clinical development and licensing were also involved. This involvement was improvised, not planned. Team members used every source, turned every stone. Personal contacts, conferences, the Internet, industry databases, and science journals were all searched. Furthermore, ad hoc advice from a number of colleagues, near and distant in the organization, was solicited. The involvement of many people in the identification effort resulted in a buzz—many people knew that a search was going on—which proved particularly beneficial in this case. An employee in a distant subsidiary called in about the molecule that became the *raison d'être* of this project.

Pre-screening. Having decided that the molecule looked interesting enough to pursue, the project manager and two colleagues from business development/licensing assembled available public information. As during the identification phase, they used many different means to find the knowledge they needed. The project manager took the lead, identifying sources of information through conference proceedings, Internet search, an industry database, and personal contacts. The other two members were then asked to follow up the leads. The team then met to reconcile what they had found. The information reaffirmed that the molecule had a good fit with the strategic plan, but the team also agreed that it needed to ask for expert input regarding some issues. They asked around the Alpha unit for advice which resulted in contacts made with two clinical experts from other Pharma units. One of the experts in particular recommended going ahead. The data looked solid and he had also heard positive comments about the licensor's researchers at a conference. Regulatory concerns were addressed by advice from two external experts retained by a preceding project (AlphaOne). This important information was found in the AlphaOne project report. The team members also had access to former AlphaOne members who—time permitting—were encouraged to support the AlphaTwo effort by their line managers. As it dawned upon the team that they would probably face competition over the molecule, two external consultants were retained to help polish the team's value proposition to the licensor. The consultants were not considered very useful, however, and the relationship was discontinued. The team decided to contact the licensor for more information. Four team members, including two specialists who joined only for this part of the pre-

screening phase, visited the licensor and liked what they saw. Having solicited top management support (results were presented in written and verbal form to the Senior Vice President of product development) and input from an external pharmacology expert the team signed a confidentiality agreement and moved on to the research phase.

Research. The research phase is key in every in-licensing project. This is where the potential of every aspect of a molecule is assessed, and it is also this phase that requires the most resources. The end result is a presentation to top management addressing a number of issues: How does the compound fit with corporate, therapeutic area and portfolio strategy? What is the profit potential predicted by market forecasts and financial models? What is the licensee's freedom to operate? What is the expected minimum acceptable profile regarding efficacy, safety, and compliance? How reliable is the licensor regarding scientific, manufacturing, and marketing skill? What are the potential strategies for product development? What milestones and external factors should be considered in the contract? In order to address these issues, AlphaTwo went through a series of steps.

(1) Setting up the team. The project manager and a subordinate put a lot of effort into putting together the team for the research phase. This involved a number of steps. First, deciding which functions needed to be intimately involved. Not every function needed to be consistently represented. Second, finding one ultimately responsible "core team member" for each function. Third, identifying "support team members" assisting the core team members. In particular, key experts were formally assigned as support members. Most support members were not assigned ex ante, however, but retained ad hoc at the initiative of a core member as the process unfolded. In this context, the project manager made a proactive effort to involve a few very young scientists to take advantage of on their still fresh contacts with their graduate schools. The stated objective of the two-tier team structure (core v. support), illustrated in Figure 2, was that it enabled an integration of the need for control and accountability on one hand and the need for resources to find lots of critical information in a short time on the other.

Insert Figure 2 about here

(2) Kick-off meeting. Having put together the research team, the project manager gathered the members for a kick-off. The agenda included briefing of team members on the history of the project, distribution of the data obtained from the licensor, communication of ground rules, and development of work plan and meeting schedule.

(3) Analyses by line functions. The responsibilities to address the critical issues were carefully allocated among the core team members. The analytical process can be exemplified with the work of AlphaTwo's pre-clinical representative (PR). Having obtained all material from the licensor, the PR proceeded to address issues related to pre-clinical development. The PR's main expertise was in toxicology. Therefore, he pursued that area himself. The other pre-clinical area that was important in this case, metabolism, he knew less about. Hence, a support member was assigned to analyze metabolic issues. The PR started to analyze the toxicology tests that had been performed by the licensor along a number of dimensions: type (preliminary tolerance, number of weeks, etc.), species (rat, dog, monkey), status (done, planned, not done/planned), sources, and implications. As he examined all the previously conducted tests a number of knowledge gaps and issues became apparent. The PR used a number of sources to find the data he was looking for. Having checked with the project manager, he contacted the licensor to ask additional questions. Some were answered, some not. He tapped his personal network for cues (a colleague from another unit, a university professor), searched proprietary databases, and read the project report from a prior in-licensing project (AlphaOne). Finally, he assembled a lab team to conduct a few tests of his own. In the end, the PR had enough data to feel prepared for the next team meeting.

(4) Integrative team meeting. The core team met to share what they had found, to integrate early results, to discuss critical issues and to refine the work plan. On one hand, the licensing representative informed the team that the licensor pressed for an early response. On the other hand, some core team members still had issues that they felt needed attention. This tradeoff was discussed, and it was decided that some more time and information was needed before the upcoming visit to the licensor's site. As a result, two external experts were hired for pointed advice. A date was set for a final meeting to prepare for the site visit.

(5) Preparation for site visit. The project manager communicated extensively with the licensor in the days leading up to the teams site visit in an effort to make sure all outstanding issues would be addressed on arrival. Furthermore, the core team had a brief phone conference making sure that everyone had had his or her say prior to the visit.

(6) Site visit. Four core team members led by the project manager visited the licensor. As they arrived, all additional information they had asked for was presented in neat piles.

(7) Integrative team meeting. The core team met for a debriefing after the site visit. Everyone was satisfied with the level of detail they had obtained, and they were also very excited about the molecule.

(8) Preparation for final report. As a preparation for the final report to be presented to top management, two consultants were retained to help the team craft an attractive value proposition. Furthermore, based on some regulatory issues brought up in the project report of AlphaOne, the PM decided to bring in an outside opinion before concluding the research phase. This external regulatory expert turned out to be as

positive as the rest of them. The core members responsible to take the lead in putting together the report integrated the findings.

(9) Integrative team meeting. The team met one more time before the presentation to top management for a final preparation and to share last minute information and insights.

(10) Top management presentation. The presentation to Pharma's top management went well. Afterwards, most of the time was spent discussing negotiation tactics. Everyone really wanted to acquire this molecule.

Capture. Preliminary negotiations started before the research phase was concluded. The main people involved were the project manager and a senior dealmaker from the licensing function. But a clinical expert and representatives from patent and finance also took part. Furthermore, a negotiation expert was hired to assist in thinking creatively about deal structures. The inclusion of a clinical expert proved particularly useful when, at one stage of the negotiations, the licensor came up with new data. The clinical researchers concluded that the new data was very good news, which was swiftly integrated into the negotiations.

At first, for reasons beyond their control, the team seemed to have lost this battle for the molecule to a competitor. The competitor had a more reputable brand name in the particular area, which was the reason stated by the licensor for its decision. Nevertheless, the way in which the project had been managed was regarded as a success corporate-wide. The team was obviously disappointed by the outcome, but still, within a week they started to work on the post mortem report. The effort was driven by the project manager and started with everyone writing down main lessons learnt in emails collected by him. Next, all members met during an afternoon to discuss the project. The emails and the discussion were consolidated into a report by the project manager and his assistant. Based on these experiences, in a dramatic change of events Pharma got another chance to get hold of the molecule and managed to acquire it through a complex deal two years later (after the interviews for this research project were concluded). The drug has since hit the market and has already exceeded the magic number of a billion dollars in annual sales. It was Pharma's best selling drug at the time of writing.

The Case of BetaOne

The story of BetaOne is not as positive. Pharma hoped to turn the molecule in focus of this project into a blockbuster drug for a particular side effect of cancer treatment. The licensor was a mid-

sized biotech firm. An in-licensing project pertaining to molecules of the same class had recently been conducted at Beta.⁶

Identification. A business development manager, who was appointed project manager, headed the identification phase. The effort was limited to the business development function. Few other people knew about the search. The team used two means of search: long-existing personal networks and established scientific journals. This particular lead was found in a journal article.

Pre-screening. The pre-screening phase was managed by the same people involved in the identification phase with the addition of one licensing representative. All non-confidential data was gathered, which consisted of the journal article and additional conference material from the licensor. Based on the strategic plan, the team concluded that the fit was very good. Thus, the team went ahead and signed the confidentiality agreement with the biotechnology firm.

Research. The fundamental issues to be addressed in the research phase of BetaOne were the same as in AlphaTwo: strategic fit, profit potential, freedom to operate, scientific, regulatory and technical feasibility, licensor's competence, deal structure, etc. The approach, however, was very different.

(1) Setting up the team. The project manager contacted a select few line managers for lists of names of people who could potentially join for the research phase, and then called around to find people who might be available. Because of the competition for potential team members' time, the project manager was unable to recruit appropriate expertise to all key functions. The project manager had a preference for individuals who had been in the organization for some time. Thus, this was a demographically homogeneous team.

(2) Kick-off meeting. The initial meeting for the research phase was rather short. The project manager distributed the confidential documents obtained from the licensor and gave the team members a deadline. The members managing the negotiations handled all interactions with the licensor. The process was guided by a flow chart describing exactly what activities to conduct, in what order, and when.

(3) Analyses by function. Team members assessed the issues assigned to them to the best of their knowledge. It was a compartmentalized effort without much interaction between functions and virtually no external search. The experience of BetaOne's pre-clinical representative is a case in point. When she

⁶ I choose to compare AlphaTwo and BetaOne in this section since these two projects are similar in that they were both the second project of its kind to be undertaken at their respective units.

noted that some important information was missing, she did not know where to turn, and because of a tight deadline had little time to find out. Thus, in the end the pre-clinical assessment had some substantial gaps.

(4) Preparation for final report and top management presentation. At the day of the deadline, the assessments of the team members were consolidated by the project manager and formed part of the presentation to top management. The team was given the go ahead for trying to reach a deal.

Capture. Preliminary negotiations were started well before the research phase. The negotiating team was headed by the project manager and a senior licensing manager who were assisted with two other licensing representatives. There was no overlap with the people involved in the research phase. The negotiations ended in a deal in which Pharma agreed to acquire the molecule. Soon thereafter it was discovered that the very expensive active ingredient was needed in a much larger proportion per dose than was initially estimated. This made it virtually impossible to turn the molecule into a profitable drug. The problem was attributed to an insufficient assessment of formulation issues.

TEAM BEHAVIOR

The preceding account captured two fundamentally different approaches to managing core technology sourcing teams to very different effects. In this section I will show how these different outcomes can be attributed to differing team behaviors. Specifically, I will discuss the important role of search behavior. I will also show how certain patterns of communication and decision-making, by ensuring internal coordination, played an important role in enabling a productive search behavior.

Search

An important characteristic of core technology sourcing is that a lot of knowledge needed by a team is not easily available since it resides outside its boundaries and distributed across many possible locations. Some of this knowledge is relatively easy to find, and some not, and it is often difficult to know the odds before starting the search. This attribute of the search process makes search a potentially expensive activity both in terms of time, money, and internal team coordination. On the other hand, if crucial knowledge is not available to the team, the consequences may very well be disastrous. Previous research suggests that complex knowledge may require search limited to internal sources that are well-known (Hansen, 1999) or to early stages of a project (Ancona and Caldwell, 1992a). The argument is not that wider search is bad *per se*, but that the costs in terms of suffering coordination outweigh the benefits.

This focused search strategy echoes March and Simon's (1958) classic account of "local search" in organizations, which argues that organizations and organizational units tend to "satisfice" by searching for knowledge in well known places since these sources provide knowledge that is "good enough" to solve the task at hand. In a setting of core technology sourcing, however, I find that—although by no means easy—the benefits of extensive search for knowledge at lesser-known sources outweighs the costs. In other words, local search is not good enough. I will turn to the data to explain this further.

To the Alpha teams, search was a priority and the responsibility of everyone. A mechanism used to find as much knowledge as possible and to get around high search costs was to use many search modalities of different kinds. Some of these were ambitious, such as hiring teams of external consultants, but most were inexpensive and less time consuming; for example, a cup of coffee with an old professor from graduate school, or an hour surfing the Internet. Some search efforts took a week or more to complete but most were quick initiatives lasting less than an hour spurred by the need for a particular piece of information. An AlphaTwo member recalled that "we did quite a lot of search for data we needed and we managed to find tons of stuff, but we usually didn't spend a lot of time... it was usually a quick fix". Furthermore, search was ongoing throughout the process. Thus, there was no concentration of search to the early stages in the effective teams. However, the nature of search activities changed over time. The identification and pre-screening phases were characterized by general technical and business related search combined with the search for factors that would cause the immediate discontinuation of the project. Search in later stages was more focused and detailed. An AlphaThree member explained:

We were constantly looking for more information out there... In the beginning we focused on obvious knockout factors, but once we decided to move into [the research phase] we looked for data that could help us deal with specific issues, like supply [of the active ingredient].

The Beta teams employed a simpler approach to search. Search activities were largely limited to the team leadership (the project manager and a senior licensing manager). The team leadership, in turn, limited the extent as well as the kind of search. During the identification phase, search was confined to existing long-standing relationships and scientific journals. "It's always better to turn to the people you know... you know what you get and they won't try to trick you" the senior licensing manager of BetaTwo commented. During the rest of the process, the only search modality was to approach the licensor, and almost exclusively at the end of the process in the context of negotiations. Importantly, many team members recognized the need to search for external knowledge. However, typically they had neither the time nor the knowledge of where to turn necessary to engage in productive search. Here is what a BetaThree team member had to say,

I have heard that there are a lot of new Internet sites with data on compounds in the market. I'm not sure how to find them though... I'm sure many of them require subscriptions... That's expensive and we don't have the money... Anyway, I didn't have any time to look around [during BetaThree]. I was very focused.

Table 4 summarizes the search activities in the studied teams including the number of activities pertaining to every search modality. It also includes quotes characterizing the processes and the attitudes at the two sites. The Alpha teams undertook far more search initiatives than all the Beta teams, but even more striking is the difference in search behavior over time. The Beta teams conformed to the findings of a number of product development studies (Hayes et al. 1988; Ancona and Caldwell, 1992a; Wheelwright and Clark, 1992) in that search was limited to the early stage, and to some extent the end stage, but almost no search at all was conducted at the middle stages. The Alpha teams, by contrast, conducted *more* search during the middle stages of the project than at the beginning and the end. In sum, the teams at Alpha and the teams at Beta differed remarkably regarding the amount of search, the modalities of search, and the pattern of search over time.

Insert Table 4 about here

Internal Communication and Decision-Making

There is a lingering issue of whether external search may result in information overload detrimental to performance (Reagans, 2001). The data from the Alpha teams told the story of how intense internal communication neutralized this threat to internal stability, and indeed reinforced and assisted in the building of a productive variety of knowledge inside the team. Another feature of the Alpha teams that made sure everyone was on the same page was a highly flexible decision-making process. These characteristics were manifested in two process elements. First, "integrative meetings" that were held regularly throughout the duration of the project. The meetings provided an arena for consensus decision-making, dissemination of new knowledge, and giving and taking of feedback. The AlphaTwo project manager explained: "Big decisions were always taken in the group. It was important to get everyone to accept a decision, even though they didn't always agree.... But these meetings were also really important as a way to get input and hear what the others had found out about the lead". At the early stages of the projects, team membership was typically small and team meetings were easy to arrange. As the project reached the research phase, however, things got more complicated. Nevertheless, the Alpha teams consistently held integrative team meetings along the way to ensure that every team member was tuned

into every important decision and had access to new knowledge and information. Second, numerous decisions referred to by team members as “just-in-time decisions” were made. These were decisions prompted by changed external circumstances that forced the team to adapt. Often these decisions were made by consensus. If circumstances were not conducive to this, every team member was promptly informed of the decision reached. An AlphaThree team member recalled one such occasion:

During the negotiations an issue about the compound’s half-life came up. Therefore, the project manager decided to shift the focus from supply back to formulation again. This wasn’t fun. I mean, I had spent a couple of days doing tests that turned out to be useless. But he went out of his way to let everyone know of the change and the reasons for it. There really wasn’t much to say about it. It was well done.

In all the Beta teams, the team leadership made decisions in accordance with a pre-set project plan. No integrative team meetings were held once the project entered the research phase. The only time the entire team met was for the kick-off meeting at the start of the research phase. The objective of this meeting was to inform the members in charge of research about the project, not to make joint decisions about the process ahead. This top-down approach to decision-making was motivated with a need for efficiency. Said the project manager of BetaTwo, “We are fast around here, and BetaTwo was fast. We finished on time. If we had had a lot of meetings and discussions about decisions, we wouldn’t have finished on time. And that was important. If we had been delayed a lot of other things going on had been affected.” The drawback of this approach was that a number of team member felt that their needs were not considered, which often led to a lack of motivation. A BetaOne member complained, “I didn’t have... the [knowledge] I needed to make a decent assessment... But, you know, it wasn’t as if anyone cared. They went ahead according to plan anyway.”

The data on internal communication and decision-making, quantified in terms of integrative meetings and just-in-time decisions, is summarized in Table 5. Quotes that illustrate the process are also included. As in the case of search behavior, both the number of data points *and* the pattern over time differed fundamentally between the Alpha and the Beta team, but very little within sites. Notably, in contrast to the Alpha projects, no just-in-time decisions were made in the Beta projects and no integrative meetings were held once the projects had entered the research phase.

Insert Table 5 about here

Link to Outcome

The differing sets of team behavior adopted by the teams affected the outcome in a number of ways. The following discussion of those mediators between team behavior and performance is grounded in the data, but I will also refer to previous studies that have drawn similar conclusions. I found that an important reason why the Alpha teams outperformed the Beta teams was because of the way in which their search behavior brought in a variety of *knowledge* components that the teams needed for task completion. Adopting Kogut and Zander's (1992) definition, these knowledge components consisted of know-how and information. Knowledge is regularly equated with know-how. In a context in which critical knowledge is greatly diffused, however, know-how is typically preceded by information; in particular, information on what knowledge is key (know-what), where to find it (know-where) and with whom the knowledge resides (know-who). These different aspects of knowledge are all nurtured by a search behavior characterized by the use of many search modalities of different kinds deployed throughout the process. Said an AlphaOne member,

Not only didn't we have the knowledge... we didn't know where to find it. So, the first thing we did was to get together to figure out who knew someone who might know something that could help us. That gave us a lot of good leads... This [practice of getting together] continued over time and in the end we know a whole lot more about where to turn for data.

A reason why a team process characterized by integrative team meetings and flexible just-in-time decisions was an important component of the successful teams' approach was that it provided a *coordination* mechanism. Specifically, it was a mechanism for obtaining and receiving feedback and second opinions (Edmondson, 1999), it ensured that decisions were based on real-time information (Eisenhardt, 1989) and that team members were informed about this information. This, in turn, was highly motivating for team members (Hackman, 1987), which is particularly important in a setting such as core technology sourcing in which the Not-Invented-Here syndrome is a clear threat (Katz and Allen, 1982). An AlphaThree team member commented on the intense communication fostered by the frequent meetings,

When you encounter so many issues for the first time you have to be able to ask questions and get some answers. I'm not sure that this project would have gone anywhere without those conference calls that [the team leader] put together. It sure as hell would have been much slower.

In addition to making sure that everyone was well informed of the goings-on in the project, the intense communication manifested in the integrative meetings leveraged the benefits of external search by disseminating important knowledge among team members (Sutton and Hargadon, 1996). Knowledge variety created by the deployment of multiple search modalities over time, and coordination and sharing

of knowledge nurtured by intense communication and flexible decision-making emerged from the data as two complementary forces. Without coordination and knowledge sharing, it is difficult to imagine as much knowledge in the team (including awareness of the range of different search modalities). On the other hand, knowledge sharing has little benefit without an inflow of knowledge to share.

THE TASK ENVIRONMENT

A distinguishing feature of the data is the similarity of team behavior within organizational units. This suggests that differences in the task environments, that is aspects of the organizational or extra-organizational context potentially relevant to goal attainment (Dill, 1958), facing the teams at Alpha and Beta sites respectively were important for the teams' ability to manage their tasks. Here I will explain how the task environment played a prominent role in the team process at Pharma. Specifically, I found strong links between team level behavior and three sets of organizational level factors: structure, process, and information infrastructure.

Structure

The structural context provided by the organization sets parameters within which its teams have to work. It can be enabling, but also constraining (Homans, 1950; Hackman, 1987). These structures were very different at Alpha as compared to Beta, and this organizational level variation, I found, significantly influenced team behavior. A defining characteristic of the Alpha teams was the two-tier team structure that distinguished between core and supporting team members. The total number of team members was relatively large, and in fact not always clear, but potential ambiguity and confusion were avoided by placing responsibility firmly in the hands of a small number of core team members. This structure enabled an approach in which the number of team members could be rapidly increased and decreased as the need for input varied while still maintaining sufficient control. An AlphaOne team member commented,

This team structure worked very well for us. We needed to gather so much information for the research phase... It would have been impossible without the support members who we could bring in at very short notice. After that focused effort they left us, but that didn't disrupt the process... That's what the [two-tier] team structure is for.

The Beta teams, on the other hand, were working with a single-tier team structure. Compared to Alpha's approach, one may describe it as a structure with only core team members. The impetus for this structure was that it enabled a focused and controlled process while still including all the necessary functions. "The team [structure] made sure that everyone knows who is responsible for what" BetaTwo's

project manager explained. While it did ensure a controlled process, the single-tier structure also prevented the inflow of important knowledge. Specifically, no team member had any significant time to dedicate to external search. Said a frustrated BetaTwo team member,

It was an impossible task. On one hand, I had to go through all the documents and come up with an intelligent assessment in ten days. On the other hand, to go out there to search for all the other information I needed to make an intelligent assessment would have taken me a month... Some support would have been nice.

Link to team behavior. The two-tier team structure used at Alpha directly enabled the search behavior, the communication patterns, and the decision-making process described above in a number of ways. It enabled the use of many team members—some of whom were dedicated exclusively to search—who when combined had access to a substantial and differentiated arsenal of search modalities. A two-tier team structure also ensured that a wide array of relevant information was brought to the integrative team meetings and into the decision-making process. An important feature of the decision-making process at Alpha was access to key informants coupled with unambiguous roles and responsibilities. A two-tier team structure provided both of these features. An AlphaTwo core team member commented on the team structure:

Some people who viewed us from the outside saw only chaos because of the number of people involved. In fact, we were well coordinated, but we had different roles. There was only one single person in charge of every function. We comprised the skeleton. Then, we called on people to join us as the project progressed.

Process

Organizational level factors influence the way in which the team process is regulated (Hollingshead, 1996). As in the case of structure, the chosen approaches to regulate the process were fundamentally different at the two Pharma sites. At Alpha, process issues were largely regulated by heuristics, i.e. rules of thumb that were valid unless nothing else were stated. These heuristics were institutionalized at the unit. They were not written down in project management manuals or any other documented form, and yet, the heuristics were highly explicit and when prompted, members of the Alpha unit were in full agreement and showed no uncertainty about their validity. Two heuristics in particular were practiced. The first was that the need to obtain sufficient information to make an appropriate evaluation was greater than the need for a speedy process. Said one AlphaThree member,

We always prioritize getting the information we need, even if it may take a bit of time to get it. That's the way it was then [during the AlphaThree project] and that's the way we still do it. It's never wrong to spend time finding more information on a [molecule]... If we need to speed up and skip steps in the due diligence process, it's up to [the team leader] to tell us that.

The second heuristic was that the benefits of including more people in the effort, thus responding to information requirements, were greater than the need for internal control. The same AlphaThree member explained,

There are some anal personalities out there, but... keeping the project on track is not the problem, getting the expertise we need is. Therefore, the more people we can include in the process the better.

An important point is that these heuristics were valid *unless* nothing else was stated or in case there were concerns warranting a re-direction. The significance of this pragmatic use of heuristics became particularly salient when compared to how the process was regulated at Beta. The process at Beta was illustrated in a project flow chart with activities and milestones that did not include points of possible re-direction or change of pace. The objective of the process was efficiency, and indeed, the Beta projects did all finish on time by following the flowchart. However, this came with a price, since there was no room for adaptation. A BetaTwo member recalled “we didn’t have time to check up on those formulations since we had to follow the plan. In the end, I think everyone agrees that it was a mistake to rush.”

Link to team behavior. A process regulated with heuristics stressing the need to obtain sufficient information and the benefits of including many people facilitated the search behavior at Alpha. The use of heuristics also enabled intensive communication. Explicit heuristics gave supporting team members the confidence to act (Eisenhardt, 1989). Importantly, this included the confidence to bring up issues and dilemmas with core team members. Furthermore, knowing what to do at important crossroads enhanced team members’ ability to assess tradeoffs (Adler et al. 1999). Said one AlphaOne team member, “The ground rules were clear. That made it much easier to do things without always checking in with [the project manager].”

The heuristics at Alpha is an example of a “semistructure”, which Brown and Eisenhardt (1997) found to be so beneficial at product development units characterized by fast change and uncertainty. The heuristics combined clear rules with a lot of flexibility in how to apply them. The story of management by heuristics at Alpha vs. management by flow charts at Beta also has a strong resemblance to the contrasting approaches to navigation deployed by the Europeans and the Trukese as described by Suchman (1987). The story tells of the European who starts with a plan (the flow chart) and carries out his voyage by relating his every move to that map. His effort is directed to remaining 'on course'. If unexpected events occur, he must first alter the plan, then respond accordingly. The Trukese starts with an objective rather than a plan and responds to conditions as they arise in an ad hoc fashion based on some basic principles (heuristics). If asked, he can point to his objective at any moment, but he cannot describe

the course. Suchman used the anecdote to make the point that there is a need to think more like the Trukese than the European when designing machines, but it applies equally well to the context of designing organizational processes for core technology sourcing teams. When completing a task in an uncertain environment, such as steering through turbulent waters or managing core technology sourcing, heuristics provide an important level of flexibility that a pre-fabricated plan does not.

Information infrastructure

One of the most important organizational level resources for organizational teams is the depth and breadth of information that a team has access to (Hackman, 1987). I refer to this as the “information infrastructure” to emphasize that both the information components and the connections between them are included. At Alpha there was a tight connectedness between the team and the organizational unit’s information infrastructure. First, detailed project reports from previous projects were available. These reports contained lessons learned, and it also chronicled external people and organizations that had been useful—or not so useful—during the process. This way, a substantial “know-who database” was gradually accumulated. Second, the institutionalized behavior was that when a team member needed to talk to members of past project teams, they took the time to assist whenever possible. Said a former AlphaOne member,

We always try to help the guys who are new [to in-licensing projects] around here. Even if you don’t have the time, you take some time. It’s something in the water... People are very helpful. Besides, if you don’t help out it’s not very well tolerated.

At Beta, teams conducted their work rather insulated from any organizational level information infrastructure. No project reports were available and the former team members very rarely made themselves available as sounding boards. “People are very busy here. You really want to avoid taking their time... In particular if the questions you have are not very crisp and very short.”

Link to team behavior. Connectedness with the organization’s information infrastructure enabled the use of multiple search modalities at Alpha. In particular, the effectiveness of the various search modalities used was considerably enhanced since organizational level information existed that guided team members in their search. Connectedness also enabled intense communication, and being able to draw upon past experience increased the teams’ capability to make the right decisions, strike the right tradeoffs, as well as to involve the right decision-makers. Said an AlphaThree team member,

I got enormous value out of those project reports. It was all there. The people to talk to, the issues to look for, the data sources... We could bring in the same experts to help us with some tough decisions.

The notion that it is important for an organizational unit to provide information to its teams is certainly not a novel insight (Allen and Cohen, 1969; Hackman, 1987). Some would simply call it common sense. The fact remains, however, that the Alpha unit was far more effective at providing important information to their teams, which suggests that reality is rather more complex. Furthermore, while the preceding discussion about structure, process and information infrastructure gives powerful support to the conjecture that the task environment has a strong influence on core technology sourcing teams, it still does not provide an explanation for the fact that AlphaOne lagged substantially in effectiveness compared to the other two teams at Alpha despite that the teams shared the same task environment and deployed the same search behavior and decision-making procedures. The answer that I found to this puzzle is discussed next.

THE BEHAVIOR OF PREVIOUS TEAMS

In a thirteenth century essay, the famous Greek scholar Dionysios explored the workings of the ecclesiastical hierarchy that regulated the political machinery of ancient Greek states. In doing so, he uncovered a three dimensional organizational form (Hagstrom and Hedlund, 1997). He observed that the ability of political parties to engage in *action* rested on their *position*, which ultimately depended on their *knowledge*, which was “fleeting and ever changing.” With a slight alteration of language this ancient observation lends an important insight to the story of the teams at Pharma. If the team is the relevant action unit, and the task environment provides the team’s position, then one dimension is still missing; namely, the ever changing knowledge. In a divine setting, the three dimensions coincide. God’s undisputed top spot in the hierarchy is matched with his capacity as all knowledgeable and all-powerful to take action. In an organizational setting populated with mere mortals, however, the dimensions are differentiated. Just as team action is dependent on organizational factors such as the information infrastructure, these factors are in turn dependent on the fleeting and ever changing knowledge of the organization. Importantly, knowledge evolves only slowly over time and ample research has shown that this evolution is path-dependent (Nelson and Winter, 1982). This pool of changing knowledge provides a valuable resource to every new team, which through its behavior contributes to it and hands it over to the next team.

The importance of previous teams’ behavior is apparent in my research on Pharma. Consider the pre-screening phase of AlphaThree during which external expertise was successfully deployed to resolve a toxicology concern. In order to go outside the team boundaries to consult an expert (team action), there

had to be a support team member available with the time and resources to do that (task environment). This team member needed to know who to turn to, and this “know-who” was found in a project report. In order for this knowledge to be available in the first place, however, a previous project must have gone through an experience resulting in the retention of the relevant knowledge (previous teams’ behavior). An AlphaThree team member’s comment illustrates this point:

I can’t emphasize enough the importance of the guys that worked with [AlphaOne]. We learned tremendously from their work, and we would never have known about those...tox experts if it weren’t for them.

This may sound like a minor incident, but when taken together, over time it is a vast array of such small incidents that builds the mosaic of components which constitutes an organization’s information infrastructure; an infrastructure that is fleeting and ever changing.

Importantly, since an organization’s knowledge is highly path-dependent, the mere presence of retention mechanisms, such as project reports, does not guarantee an effective information infrastructure. The path an organization’s teams take will determine what experiences those mechanisms will capture. One of the more popular concepts in the product development and operations management literature related to learning and capability development is “learning-by-doing” (Arrow, 1962; Rosenberg, 1982; Argote and Epple, 1990; 1996). If learning-by-doing means to use a highly defined team process with a *stable* team composition over time across projects aiming to become more efficient for every iteration, that is the approach that was chosen by the Beta teams. My data shows that this approach was fast but not very effective. The Alpha teams, on the other hand, adopted an approach characterized by *variation*. Specifically, every team’s composition varied remarkably across projects. Figure 3 illustrates the difference between the two sites. While the numbers and kinds of team members, as well as the phases in which these members were involved, were all but identical across the teams at Beta, these dimensions varied wildly at Alpha.

Insert Figure 3 about here

Link to the task environment. The Alpha teams did better than the Beta team, but more than that; they did better over time. This pattern is summarized in Figure 4, which provides a graph of how the studied projects performed. An important reason for the pattern, I found, is that product development in a context in which critical knowledge is spread outside the team boundaries follows a different logic as compared to traditional internal product development. A key characteristic is that every project is

unpredictable and significantly different from the next. In this environment, learning-by-doing, which is designed for a stable environment and promotes efficiency and precision, does not make sense. It hampers flexibility and fundamentally disconnects the team from the dynamic external pool of knowledge upon which it is dependent (Sinclair et al. 1997). In such a context, the team process has to be flexible enough to adapt to the external context and it has to have the ability to know how to align with it and prosper from it. An approach of variation is much better suited to such a context. An AlphaTwo team member commented on the in-licensing process,

We don't know beforehand what [knowledge] we'll need. We do know, however, that most of it won't be found here [inside the team]. Therefore, the more varied the experience of previous teams, the greater chance we'll find something useful there.

Insert Figure 4 about here

A key reason why a strategy of using a variety of team compositions over time developed capabilities for core technology sourcing is that it created knowledge options. By using many team members of different kinds, the team is provided with a differentiated set of knowledge. Since a lot of the most specialized knowledge resides outside the team's boundaries, a crucial part of this knowledge set is the information needed to access it (know-what, know-where, know-who). If the organization has effective retention mechanisms, the amount of information that teams can draw upon grows over time as a multitude of different individuals pass through the teams. As this knowledge is encoded in the organization's information infrastructure, the number of knowledge options grows. Second, variation creates an ability to exercise knowledge options. As the organization, the teams, and the team members get used to managing a lot of variation, they become better at using their knowledge options timely and effectively. Notably, the participatory integrative team meetings and the project reports aided this learning at Alpha. An important point here is that knowledge options and the ability to use them co-evolve. A comment from AlphaTwo's project manager elegantly illustrates this point:

We [in-licensing team members] have to be good jugglers. We have to keep a lot of balls in the air. There are so many different pieces to keep track of... As we move along and do more projects we will have more balls to juggle, but that's only because we've become better at juggling.

The implications of the foregoing discussion are illustrated with the case of AlphaOne, which substantially lagged the other two Alpha projects in performance. Notably, this was the first project of its kind in that a molecule of this particular therapeutic class had never been in-licensed before. Hence, no significant pool of knowledge options was passed on to the team and the information infrastructure

provided little that was useful. The process was a frustrating one for the team members. They deployed a strategy of using as many search modalities as they could, but they had few known modalities available to them, which was reflected in the relatively small number of search initiatives taken. Some productive leads were found and through extensive communication these were shared in the team. Often, however, it took a long time to find relevant information. Therefore, the process was not a great success in the end. The hard work of the AlphaOne team produced a lot of benefits for the AlphaTwo team, however, that in turn gave the AlphaThree a rich pool of knowledge options to mine. The following quote from an Alpha project team leader illustrates the dynamic:

AlphaOne was the first project based on a lead [of that therapeutic class]. Mistakes were made, lessons were learnt, which were then applied in AlphaTwo and AlphaThree. In particular, people were brought in ad hoc in a good way and [the team members] knew where to look and what to look for.

Although novel in the team behavior discourse, the notion of knowledge options has been used in organization theory. For example, Kogut and Zander state that “the cumulative knowledge of the firm provides options to expand in new but uncertain markets in the future” (1992). In innovation-driven firms, then, product development teams are often the units to exercise those options (Leonard-Barton, 1992). Similarly, Gresov and Drazin (1997) argued that organizations facing conflicting demands are better off the more options are available to them. A team involved in core technology sourcing fit this profile of facing conflicting demands, reflected in a difficult knowledge-coordination tradeoff. Finally, conceptualizations of new organizational forms in dynamic and uncertain environments, notably Hedlund’s “heterarchy” (1986; 1994) and Ciborra’s (1996) “platform organization”, have stressed the availability of as many options as possible to ensure the capacity to launch as many organizational units of different kinds as possible. Hedlund (1994) points to the need for many interdependent “potentially combinable and recombable parts” to strike a productive balance between exploitation and exploration (March, 1991). These models map well onto a drug development unit that launches teams with a variety of team compositions. In the teams literature little has been said about knowledge options. A notable exception is Austin (2000) who found that the more people the team members know to seek assistance from the better for team performance. This finding has a parallel in the work on social network theory by Lin (1999) who found that the debate of the relative benefits of strong and weak ties notwithstanding (Granovetter, 1973), the more “extensive” the ties available the better.

CORE TECHNOLOGY SOURCING AND ARCHITECTURAL DEPENDENCY

Comparing and contrasting the behavior and performance of teams at Alpha and Beta is a story in three acts. The first is about how the Alpha teams continuously used many search modalities of different kinds coordinated with intense communication and transparent and flexible decision-making, while the Beta teams used a few well-known search modalities at the beginning and end of the project. The second is about how search activities and decision-making among the Alpha teams were enabled by the organizational unit through a two-tier team structure, a process regulated by heuristics, and a close connectedness with the information infrastructure. This was in contrast to the Beta teams that worked with a single-tier team structure, a process regulated by flow charts, and a relative independence from the unit's information infrastructure. The third and final act is about how the Alpha teams worked with a pool of knowledge options molded over time through large variation in team compositions within and across teams. Meanwhile, the Beta team deployed team compositions that were virtually identical across projects.

One might argue that this story of the three successful teams at Alpha and the three less successful teams at Beta is a story that is implausibly black-and-white. However, while it is reasonable to expect the real world to present stories with shades of gray, when looking closer at the studied setting there are two related reasons why the distinct and diverging patterns of how to manage core technology sourcing teams at the two sites make sense. The first reason has to do with the overall regime of the product development process. Beta modeled its in-licensing projects on its internal drug development projects. In internal drug development, once the molecule has entered clinical development extensive external search for knowledge does not make sense. After all, the knowledge upon which the molecule is based, the core technology, is found internally. In this case, a disciplined approach makes a lot of sense. Clinical development is very expensive, and hence the need for speed is great. As a consequence, decision-making is often top-down, processes are regulated with detailed flow charts, and so on. Another strong reason to model in-licensing projects on internal projects in this manner is that the tasks and the processes pertaining to internal drug development projects are well known. An additional reason is to avoid symptoms of the Not-Invented-Here syndrome. If the scientists regard in-licensed molecules as a "second pipeline," there is a risk that they would regard them as less important. The solution, hence, is to treat the in-licensed compounds essentially the same way as internally developed ones. This, in short, was

the regime applied to the in-licensing process by the managers at Beta.⁷ It was a regime of integration with internal constituents prioritizing the need for internal organizational uniformity and coordination. At Alpha, by contrast, executives did acknowledge the risk of N-I-H, but they nevertheless modeled the in-licensing projects around the need for external knowledge. The strategy chosen to fight N-I-H at Alpha was extensive communication. The search behavior and decision-making processes of the Alpha teams flowed from this regime that was fundamentally different from the internal development model. In essence, this was a regime of integration with external constituents prioritizing the need for external knowledge. This story of how two different regimes influenced the in-licensing process at Alpha and Beta echoes the contrasting product development models of “compression” and “experiential” identified by Eisenhardt and Tabrizi (1995). The compression model “assumes a well-known, rational process” very much like the one used at Beta. The experiential model, on the other hand, “assumes an uncertain process and relies on improvisation, real-time experience and flexibility” very much like the one used at Alpha.

The second reason why the two distinct patterns make sense is that factors in the dimensions of the team, the task environment and the behavior of previous teams are tightly inter-linked. These factors cluster together in internally consistent bundles driven by the regime chosen by management, thus reinforcing the two distinct patterns even further. Consider yet again the example of AlphaThree’s pre-screening phase during which external expertise was successfully deployed to resolve a toxicology issue. It was found that without the enabling factors at the levels of the organization and previous teams’ behavior, this crucial piece of information would not have been found. Its deployment was tightly linked to the information infrastructure, the content of which was a product of previous teams’ usage of a variation of team compositions. On closer examination, a great number of the actions taken by the studied teams were contingent on the task environment, previous teams’ behavior, or both. Importantly, the more successful the teams the stronger the links among the three dimension. While no actions taken by AlphaOne and the Beta teams were leveraged by the behavior of previous teams, a great number of the actions taken by AlphaTwo and AlphaThree were. Table 6 illustrates this pattern by breaking down the external search initiatives each team took by the number of the three dimensions these initiatives were dependent on.

⁷ The lack of connectedness between the team and the organizational unit is not an explicit part of the internal drug development regime. Rather, the reason for the pattern of minimal connectedness at Beta was that no separate procedures had been implemented for retaining knowledge from in-licensing teams. For example, project reports were only written after an FDA decision by the people involved after the end of the capture phase. The reports included few in-licensing specific records. This created a negative cycle in which important experiences were neither recorded nor solicited.

Insert Table 6 about here

I refer to this dependency of core technology sourcing teams' discretion on three fundamental dimensions (the team, the task environment, the behavior of previous teams) as "architectural dependency." The term is inspired by the work on "architectural innovation" by Henderson and Clark (1990) who made the point that in trying to understand the dynamics of innovation and firm action it is sometimes more important to understand how components are linked than to understand the components themselves. Analogously, in trying to understand team behavior, this study points to the need to consider how factors at different levels of analysis are linked and how team behavior is dependent on these relationships. This is more than simply dependence on organizational level measures that can be put in place from one day to the next; the information infrastructure in particular would be less valuable without a rich pool of knowledge handed down by previous teams. But architectural dependency is also more than just path-dependency. First, path-dependency typically refers to how the actions of an organization, or an organizational unit, is dependent on how it has acted in the past. In this case, since teams are temporal units, the historical dependency is different in nature. Specifically, the action of one team is dependent on how *another* team has acted in the past. Second, factors in the task environment, such as the team structure, have a great influence on team action that is not conditioned by the behavior of previous teams. The structure deployed by the Alpha teams enabled them to devote members to search activities in a way that was impossible for the Beta teams. Fundamentally, the architectural dependency of a team is the dependency of its behavior on components configured across dimensions that are tightly linked and mutually reinforcing. When molded over time under a productive regime, such as the one adopted at Alpha, the architecture of factors upon which a team is dependent can create positive cycles of team performance at an organizational unit. Under a less productive regime, however, the cycles can spiral the other way.

In order to illustrate the significance of architectural dependency, it is useful to turn to previous research on teams. Ancona and Caldwell (1992a) found that an important team strategy to manage the external context was an "ambassadorial strategy" which involved persuading external constituencies to support the team and lobbying them for resources. The teams that deployed such a strategy performed well, those that did not performed less well. Why, then, did not all teams deploy this clearly superior strategy? One reason could be that less successful teams were not aware of this strategy, or that they did not think much of it. An alternative explanation, however, is that these teams were restrained by architectural dependency. In the first place, in order to deploy an ambassadorial strategy a team structure

has to be in place that permits team members to spend time being ambassadorial. In the second place, in order to deploy an ambassadorial strategy the team members need to know whom in the external context to be ambassadorial with. Going back to the case of Pharma, this dynamic begs the question why team members did not actively search for knowledge externally when they clearly lacked it internally. The data presented in this paper indicates it was not for want of recognizing the potential benefits of external search. In fact, many Beta team members were acutely aware of the need for external knowledge. Instead, the data strongly points to the alternative explanation for their inaction; namely, that architectural dependency constrained their action. A complaint from a BetaOne member illustrates the point:

It is all but impossible to bring in external expertise at this place. We don't have the organizational [structure] to do that, or the time... Besides, we don't know where to start looking... It would make a enormous difference if we could go outside for expertise though. We would if we could.

A central implication of using architectural dependency as a lens when analyzing team behavior is that if we do not adequately understand the nature of the links between team behavior and the underlying contextual forces that enable and constrain team action in the first place, we may be able to identify team level variables positively associated with performance, but we will not be in a position to use that knowledge as a basis for prescriptive recommendations.

The validity of architectural dependency as an interpretive key to team behavior outside the setting of core technology sourcing is difficult to assess, but there are no theoretical reasons to think that it is limited to core technology sourcing. Conditions that increase the likelihood of its validity in a given setting include temporary rather than permanent teams, high rather than low dependence on external factors, and an external context that is rapidly changing.

Outside the area of team research, this work provides an in-depth account of how teams can build organizational capabilities. Many scholars have singled out the team as a key unit for capability development (Clark, 1988; Kanter, 1989; Leonard-Barton, 1992), but few have actually provided empirical data for how this is done over time. The story of Alpha's strategy of creating knowledge options by using a variety of team compositions is particularly compelling in the context of this discourse. This research also makes the case for introducing core technology sourcing as an important phenomenon in its own right to the product development literature. Finally, an important managerial implication is that some measures to change a firm's core technology sourcing performance can be taken immediately, such as introducing a new team structure, but others, such as a fertile pool of knowledge, can take years of honing.

CONCLUSIONS

I set out to research how new product development teams identify, evaluate and integrate core technologies for new products, and a study of pharmaceutical in-licensing teams was selected for this purpose. The research was motivated by an interest to further the understanding of how teams manage a task when knowledge critical to task completion is complex and dispersed outside the boundaries of a team. A particular motivation was an interest in the knowledge-coordination tradeoff, which presents teams with contradictory and simultaneous forces for narrowing and broadening search activities.

The data obtained from a careful study of six pharmaceutical licensing teams told a story in which successful teams found a way of meeting the challenges and managing the knowledge-coordination tradeoff based on the interaction between two sets of factors: the deployment of many search modalities of different kinds throughout the project coupled with the use of intense communication and flexible decision-making. Mediated by a productive variety of knowledge and effective coordination, these factors led to a positive outcome. The less successful teams, on the other hand, modeled their behavior on internal product development projects characterized by narrow search, limited to the early and late stages of the project, and top-down decision-making. This approach left the teams unable to manage the challenges posed by the fact that important knowledge resided in their external context. In particular, the teams were typically left without knowledge critical for successful task completion. As the research progressed it became increasingly clear that team level factors only told part of the story. The effectiveness of the successful teams' approach to search and coordination was strongly dependent on organizational level factors; in particular, the way the team composition was structured, the team process was regulated, and the organizational information infrastructure was leveraged. But that was not all. I also found that the usefulness of the critically important information infrastructure was dependent on the experience accumulated by previous teams. The insight of how three dimensions of analysis interacted was captured in the notion of a team's architectural dependency, emphasizing the straightjacket on a team's discretion presented by factors in its task environment, in the behavior of previous teams and in the way these factors are linked.

In sum, I found that the search behavior deployed by successful core technology sourcing teams is different from what has been found in previous studies of product development teams. Furthermore, this research shows that in order to truly understand the behavior of a team dependent on knowledge that is complex and externally dispersed, researchers have to look beyond the team itself.

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Figure 1.

STEPS:

Identification. A core technology sourcing team is formed when a search for a molecule is launched or a promising molecule has appeared unsolicited. The identification phase begins with this team formation and ends with the decision to look closer at an identified molecule.

Pre-screening. Involves investigation of all non-confidential information available. This phase ends with a decision to approach the prospective source organization and to sign a confidentiality disclosure agreement.

Research. Starts with the acquisition of confidential data and involves the analysis of all aspects of what it would mean to finish the development of the molecule in-house: technical, commercial, organizational and strategic. The formal end of this phase is recommendations for the capture phase.

Capture. Involves the pursuit of a final agreement with the licensor and the objective is to capture maximum value, which may involve acquisition as well as the decision to discontinue the process. This phase frequently overlaps with the research phase, and iterations are common.

FUNCTIONS:

Project management. Main responsibilities include project coordination and communication with top management.

Discovery research. This function deals with issues such as the basic mechanism of action of a molecule. It is usually less involved in projects pertaining to molecules that have entered clinical development.

Preclinical development. Includes issues such as toxicology, drug metabolism, pharmaceutical science, and quality assurance.

Clinical development. Clinical pharmacology and pharmacokinetics, health economics, pharmacovigilance and bio-statistics fall into this realm.

Regulatory development. This includes regulatory affairs, quality assurance, etc.

Supply. Manages active pharmaceutical ingredients among other things.

Licensing/business development. These two functions were integrated at Pharma Corporation. Licensing handles negotiations, legal aspects, etc. Business development manages competitive intelligence, strategic research assessment, and so on.

Finance. Deals with tax matters and financial modeling.

Patent. This function consists of specialists, e.g. by region and patent type.

Table 1.

Description of Teams					
Unit	Team name	Therapeutic area	Phase of development *	Duration ** (months)	Interviews *** per project
Alpha	AlphaOne	Infectious diseases	Phase III	10 (June Year 1-March Year 2)	9
	AlphaTwo	Infectious diseases	Phase III	12 (Dec Year 1-Nov Year 2)	12
	AlphaThree	Infectious diseases	Phase III	5 (Dec Year 2-April Year 3)	11
Beta	BetaOne	Oncology	Phase III	6 (Nov Year 1-April Year 2)	9
	BetaTwo	Oncology	Phase II	5 (Sept Year 2-Jan Year 3)	8
	BetaThree	Oncology	Phase III	6 (Dec Year 2-May Year 3)	9

* The phases of drug development:

Pre-clinical: Trials with the goal to amass sufficient data on the candidate drug to warrant the expensive step into clinical trials.

Phase I: Clinical trials with healthy volunteers. Focus on safety.

Phase II: Clinical trials with afflicted patients. Focus on efficacy.

Phase III: Large scale trials with the goal to find proof of efficacy and safety in long-term use.

Approval: Documentation submitted to the authority responsible for drug approval.

** The exact years during which the projects took place have been disguised at the request of Pharma Corporation.

*** Not including numerous phone calls and follow-up conversations.

Table 2.

Team Effectiveness			
Case		Average score (1-5) *	Rank
AlphaThree		4.8	1
Examples	"The process went extremely well... efficient and effective" "We knew exactly what to look for, and we had the skills to do it well"		
AlphaTwo		4.2	2
Examples	"[The process] was very fast and very good" "Our... effort really impressed [everyone]"		
AlphaOne		3	3
Examples	"It was tough... We had very little [knowledge] to go on "Given the circumstances, I'd say we did OK. It was exhausting though."		
BetaTwo		2.5	4
Examples	"You know, we should know how to do this right by now. But instead, it was another failure as far as I'm concerned" "Sometimes I wondered if anyone knew what we were doing"		
BetaOne		2	5
Examples	"My first question was: 'What is due diligence?' I still don't know" "We just did not do a good job" "I didn't have... the [knowledge] I needed to make a decent assessment"		
BetaThree		1.5	6
Examples	"We didn't have anywhere to go [for feedback]... It was very frustrating" "Did we learn from past mistakes? No, we did even worse" "It was embarrassing... we hadn't noticed the toxicology issue"		
* Calculated as the simple unweighted average across criteria and raters. Details of the performance measure is discussed in the methodology section.			

Table 3.

Key data			
Site		Alpha	Beta
Identification	Ongoing search was communicated in the organization	Yes	No
	People outside the business dev. function were part of search effort	Yes	No
Pre-screening	In addition to the information made available by the licensor, databases and personal contacts were tapped for public information	Yes	No
	Project reports from previous projects were used to identify areas of potential concern and relevant expertise	Yes	No
	Before putting forth a recommendation to top management, and outside opinion was sought	Yes	No
Research	Procedures to obtain necessary formal support was integrated in the team structure	Yes	No
	Team members engaged in many search activities of different kinds	Yes	No
	The team had frequent integrative meetings	Yes	No
	At a number of occasions, the process was redirected in response to unforeseen circumstances	Yes	No
	The process was characterized by intense use of email, phone conferencing and informal meetings	Yes	No
	Project reports from previous projects were used to identify areas of potential concern and relevant expertise	Yes	No
Capture	After conclusion, a detailed project reports were filed with key lessons learnt and important relationships forged	Yes	No

Figure 2.

Table 4.

Search					
Phase		Identification	Pre-screening	Research	Capture
	Search modality				
AlphaOne	Internal expertise				
	Technical	2	1	4	0
	Process-related	0	0	2	2
	External expertise				
	Technical	1	0	2	0
	Process-related	0	0	0	0
	Databases				
	Paid services	1	2	6	0
	Free services	0	1	0	0
	Project reports	0	0	0	0
	Source organization	1	3	2	8
	Total number of search initiatives	5	7	16	10
	Grand total				38
Examples	"This [team member] went out there to put together an intelligence database. It was a huge job finding all the data. But it was also a very valuable job... It made our sales pitch to the licensor look really professional"				
	"There is so much uncertainty involved in finding the information we need for a [core technology sourcing] project. Therefore, it made much more sense with many small bets than a large one"				
AlphaTwo	Internal expertise				
	Technical	3	2	5	2
	Process-related	3	4	5	2
	External expertise				
	Technical	0	2	4	0
	Process-related	0	0	0	0
	Databases				
	Paid services	1	1	4	0
	Free services	0	1	1	0
	Project reports	2	2	4	3
	Source organization	1	3	6	7
	Total number of search initiatives	10	15	29	14
	Grand total				68
Examples	"I always want to have a couple of researchers fresh out of graduate school on my team. Their networks are very different from ours, which is great when you need to look for a lot of new information. This is particularly important in [core technology sourcing]... old road maps don't always work"				
	"To find external experts to help you out is always important in [core technology sourcing]. If you don't know a lot, you need them for technical and regulatory knowledge. If you do know a lot, you need independent opinions to control the N-I-H beast"				
AlphaThree	Internal expertise				
	Technical	2	2	4	0
	Process-related	0	4	7	5
	External expertise				
	Technical	0	2	3	0
	Process-related	0	0	0	0
	Databases				
	Paid services	1	1	5	0
	Free services	1	1	0	0
	Project reports	2	5	5	0
	Source organization	1	5	5	8
	Total number of search initiatives	7	20	29	13
	Grand total				69
Examples	"The fact that people may only be able to be involved for a certain time means that more people gets involved. This is a good thing in a [core technology sourcing] project. More often than not the knowledge required for a quick high-quality evaluation is found in the team members' network. The more team members, the larger the network and the bigger the chance that we get the knowledge that we need"				
	"Sometimes the licensor won't give you what you want. You have to go with your gut feeling... Is information withheld? This spurs creative search that will hopefully give you a proxy. A common example is the cost of synthesizing a molecule. Sometimes that information is proprietary. Then, you have to be willing to go out on a limb. You have to go out to put the puzzle pieces together, like a detective."				
continued					

Table 4 (cont.)

Search behavior (cont.)					
Phase		Identification	Pre-screening	Research	Capture
	Search modality				
BetaOne	Internal expertise				
	Technical	0	0	0	0
	Process-related	0	0	0	0
	External expertise				
	Technical	4	0	0	0
	Process-related	0	0	0	0
	Databases				
	Paid services	8	0	0	0
	Free services	0	0	0	0
	Project reports	0	0	0	0
	Licensor	1	2	0	5
	Total number of search initiatives	13	2	0	5
	Grand total				20
Examples	"We failed to bring in any outside opinion. We did not know where to look... It would have been great to bring someone in who was not politically involved"				
	"It is all but impossible to retain external consultants at this place. We have no money to do that, and if I would insist it would take too long to get approval to make sense. As far as I know it has never been done."				
	"It is important that we don't confuse the licensor by presenting too many faces. Therefore, we didn't ask them for more data"				
BetaTwo	Internal expertise				
	Technical	0	0	0	0
	Process-related	0	0	0	0
	External expertise				
	Technical	0	0	0	0
	Process-related	0	0	0	0
	Databases				
	Paid services	1	0	0	0
	Free services	0	0	0	0
	Project reports	0	0	0	0
	Licensor	1	2	0	4
	Total number of search initiatives	2	2	0	4
	Grand total				8
Examples	"There was a big debate about whether the compound really met a medical need... No external expertise was brought in to resolve the issue"				
	"We didn't have time to look for the information we needed. Besides, we didn't know where to find it"				
BetaThree	Internal expertise				
	Technical	0	0	0	0
	Process-related	0	0	0	0
	External expertise				
	Technical	9	0	0	0
	Process-related	0	0	0	0
	Databases				
	Paid services	9	0	0	0
	Free services	0	0	0	0
	Project reports	0	0	0	0
	Licensor	1	1	0	7
	Total number of search initiatives	19	1	0	7
	Grand total				27
Examples	"The market for compounds is very competitive. We try to limit the number of people who know about our projects. We don't want to get the attention of our competitors if we don't have to. Then we risk facing a situation with multiple bidders, which is never beneficial to us. Therefore, we avoid looking for information externally if we can"				
	"During the [research phase] we focused on the information we had... We really didn't leave the building"				

Table 5.

Decision-making					
Phase		Identification	Pre-screening	Research	Capture
	Type				
AlphaOne	Integrative meetings*	1	2	3	0
	Just-in-time decisions**	0	1	6	4
Examples	"...it turned out that an early application for clinical trials had been closed down after the discovery of toxicity. We decided that we needed expert advice and brought in two consultants." "We already had the letter of intent, but [the clinical representative] called a snap meeting... We decided that the final negotiations had to be delayed."				
AlphaTwo	Integrative meetings	3	1	3	0
	Just-in-time decisions	0	1	2	1
Examples	"After the phase III results were announced things changed. Suddenly there was a lot of stress... At the team meeting we decided to prioritize the sales effort instead." The team leader on bringing in external expert advice just before an important decision: "... you need independent opinions to control the N-I-H beast."				
AlphaThree	Integrative meetings	1	1	3	0
	Just-in-time decisions	0	0	3	3
Examples	"The efficacy data looked much worse than expected and we decided that we needed more time... After a lot of haggling with [the licensor] we got what we asked for." "We gave our recommendations one by one, like a jury, and the verdict was harsh."				
BetaOne	Integrative meetings	2	2	0	0
	Just-in-time decisions	0	0	0	0
Examples	"It would have been great to bring someone into the decision-making who was not politically involved" "In hindsight, our decision to sign the agreement was too quick"				
BetaTwo	Integrative meetings	1	1	0	0
	Just-in-time decisions	0	0	0	0
Examples	"It actually wasn't clear whether the lead satisfied a medical need. Blood transfusions essentially treat the same condition... We didn't really have the time to talk about this before we had to decide to move on." "You know, we had to stick to the plan. We didn't have time to check every angle, ask everyone about their opinion."				
BetaThree	Integrative meetings	2	2	0	0
	Just-in-time decisions	0	0	0	0
Examples	"It would be good to have some more input before we took the decision, but no one around here knows the issues." "The NPV looked really good, but then this formulation issue blew up right at the end. It was devastating, a knock-out. We should have taken that into consideration much, much earlier."				
* All core team members get together to brief each other, integrate findings and make key decisions					
** Decisions prompted by new and unexpected information					

Figure 3.

Figure 4.

Table 6.

Numbers of search initiatives and dimensions of dependency				
Initiative was dependent on team action		Yes	Yes	Yes
Initiative was dependent on factors in task environment		No	Yes	Yes
Initiative was dependent on team heritage		No	No	Yes
Alpha	AlphaOne	26	12	0
	AlphaTwo	40	24	12
	AlphaThree	22	26	21
Beta	BetaOne	20	0	0
	BetaTwo	8	0	0
	BetaThree	27	0	0
				Total
				38
				68
				69
				20
				8
				27