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FINDING A PARTNER:

SELECTION UNCERTAINTY IN ALLIANCE FORMATION

A Dissertation

Presented to the Faculty of the Graduate School

of Cornell University

in Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

by

Hitoshi Mitsuhashi

January 2001

BIOGRAPHICAL SKETCH

Hitoshi Mitsuhashi was graduated from Keio University, School of Policy Management, Tokyo, Japan, in March 1994. He was graduated with the degree of M.S. from Cornell University, New York State School of Industrial and Labor Relations, Ithaca, New York, in August 1996.

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CHAPTER ONE: INTRODUCTION

Uncertainty has been one of the core research issues in organization research for several decades (Donaldson, 1995; Evan, 1966; Katz & Kahn, 1966; Scott, 1992; Simon, 1957; Terreberry, 1968; Thompson, 1967; Thompson & McEwen, 1958). It is a crucial factor in this field because organizational strategies, structures, and actions can be viewed and analyzed as a result of responses to (1) uncertainty in task environment (Chandler, 1962; Galbraith, 1973; Lawrence & Lorsch, 1967; Thompson, 1967), (2) uncertainty about appropriate behavior and actions for increasing legitimacy (DiMaggio & Powell, 1983; Meyer & Rowan, 1977), (3) uncertainty about future contingencies in exchange relations (Williamson, 1975, 1981, 1985), and (4) uncertainty about resource inflows from other organizations on which organizations are dependent (Blau, 1964; Emerson, 1962; Jacobs, 1974; Pfeffer & Salanck, 1978). Because of its dominant influence on organizational behavior, an analysis of uncertainty offers us an opportunity to capture and research organizational life. This research, following tradition, is another study on organizational management of uncertainty and, in particular, uncertainty that organizations face in forming research and development (R&D) alliances.

There is little doubt that American companies have been increasingly creating R&D alliances with other organizations as part of their business strategy (i.e., Doz & Hamel, 1998; Gomes-Casseres, 1996; Kanter, 1989; Porter, 1985). An alliance is defined as "a novel form of voluntary interorganizational cooperation that involves significant exchange, sharing, or codevelopment and thus results in some form of enduring commitment between the partners" (Gulati & Gargiulo, 1999: 1440). It can

also be defined simply as "contractual asset pooling or resource exchange agreements between firms" (Stuart, 1998: 668).

In general, alliances enable organizations to achieve the following objectives: (1) fast access to technology, knowledge, and skills outside organizational boundaries, (2) increasing economies of scale by pooling resources, (3) sharing risks for costly projects that exceed a single firm's affordability, and (4) managing uncertainty through sharing strategic information with competitors (*Business Week,* 1988, 1993; Doz & Hamel, 1998; Gomes-Casseres, 1996; Kogut, 1988; Oliver, 1990; Pfeffer & Nowak, 1977; Piore & Sable, 1984; Powell, 1990).

An important factor underlying the effectiveness of R&D alliances is the selection of alliance partners (Doz & Hamel, 1998; Geringer, 1990; Gulati, 1998; Gulati & Gargiulo, 1999; Simonin, 1997). Partner selection is crucial because a major motivation of R&D alliance formation is to procure resources and knowledge that other organizations possess and combine them with an organization's own strengths to overcome specific weaknesses (Doz & Hamel, 1998; Chowdhury, 1989; Simonin, 1997). Geringer (1991: 55-59) noted that "the specific partner chosen can influence the overall mix of available skills and resources, the operating policies and procedures, and the short and long term viability" of alliances.

Organizations, however, do not always know a priori which partners will best serve their interests. This is what I term *selection uncertainty.* In general, uncertainty is the "absence of information" about causal mechanisms (Daft, 1987: 285): "the individual does not know the probability distributions connecting behavior choices and environment outcomes" (March & Simon, 1956: 133). Information is "'news' for the organization when it is a first appearance of some sign of how the future is going

to be, in a respect crucial for the organization" (Stinchcombe, 1990: 3). Uncertainty describes a state in which organizations do not have enough information about contingencies to make decisions. Selection uncertainty describes a state in which organizations do not have information about prospective partners that they need to engage in collaborative relationships. Selection uncertainty consists of three elements: (1) technical competence, (2) contribution, and (3) commercial success (Geringer, 1990; Gulati & Gargiulo, 1999; Gulati & Singh, 1998; Larson, 1992; Ring & Van de Ven, 1992; Sobero & Schrader, 1998).

The first element of selection uncertainty refers to ambiguity about prospective partners' technical competence that is required to achieve the goals of alliances. Because scientific knowledge and technical know-how are not always explicit (Collins, 1985; Collins & Pinch, 1993; Nelson & Winter, 1982), organizations are not able to assess prospective partners' technical capabilities before beginning actual collaboration. Another factor in this element of selection uncertainty is what agency-theory literature calls *adverse selection*: "the misrepresentation of ability by the agent" (Eisenhardt, 1989: 61). Since organizations seeking alliance partners cannot completely verify claimed capabilities at the time of selection, prospective partners may misrepresent their capabilities and thus increase the complexity of finding other organizations possessing the needed technical competence.

The second type of selection uncertainty refers to ambiguity as to whether prospective partners will make their best efforts after collaboration agreements are made (Williamson, 1975). This uncertainty comes from what agency-theory literature terms *moral hazard*. It means that partners "may simply not put forth the agreed-upon effort," and that they are "shirking" (Eisenhardt, 1989: 61). This uncertainty also

relates to what sociological literature terms *trust*. Trust is defined as "a set of expectations shared by all those involved in an exchange" (Zucker, 1986: 54) and, more specifically, "a type of expectation that alleviates the fear that one's exchange partner will act opportunistically" (Baradach & Eccles, 1989: 100). For instance, alliance partners may not send their best scientists and engineers to joint ventures and research consortiums, so that partners can protect core knowledge and know-how from their competitors (Browning et al., 1995; Gibson & Rogers, 1994).

The third type of selection uncertainty refers to ambiguity as to whether alliances are financially reasonable and whether they will enable organizations to make commercial values and, ultimately, achieve goals. Completion of R&D projects typically requires a large financial investment and long-term commitments, making it necessary for organizations not only to predict future market states and technological advancements, but also to reduce uncertainty as to whether organizations will be able to deliver values from proposed alliances.

Although previous research agrees that the selection of alliance partners is crucial and that reduction of selection uncertainty is mandatory for high-performing alliances, little is known about how organizations reduce selection uncertainty and find appropriate partners who can serve their best interests. There are two reasons for our limited understanding of this issue. First, previous research tends to focus on interorganizational activities and relations after alliance formation and overlook those prior to it (i.e., Arino & Torre, 1998; Elg & Johansson, 1997; Grandori & Soda, 1995; Hill & Hellriegel, 1994; Human & Provan, 1997; Inkpen & Beamish, 1997; Inkpen & Dinur, 1998; Lorenzoni & Lipparini, 1999; Ouchi & Bolton, 1988; Sobero & Schrader, 1998). Although these studies unfold such questions as how allying

organizations maintain and improve relations, how they exchange information and resources, and how they resolve problems, it is difficult to learn from them how organizations reduce selection uncertainty and how organizations form alliances.

Second, there is not doubt that the embeddedness approach is one of the most compelling guides in alliance research (Gulati, 1998). A core argument of the embeddedness approach is that "the behavior and institutions to be analyzed are so constrained by ongoing social relations that to construe them as independent is a grievous misunderstanding" (Granovetter, 1985: 481). It points out limitations in, and raises a question for, new institutional economics (i.e., Williamson, 1975) by presuming that economic behavior is a result of "the pursuit of self-interest by rational, more or less atomized individuals" (Granovetter, 1985: 482). Because this approach proposes that economic actions should be explained by reference to not only individual motives but also social relations, researchers in alliance studies often build their foundations upon this approach and sharpen general ideas about how social relations and ties change patterns of interorganizational relations and create opportunities for, and constrains on, economic transactions (i.e., Larrson, 1992; Uzzi, 1996).

Regardless of its great contribution to alliance research, it should be noted that, with some exceptions (Larson, 1992; Gulati & Gargiulo, 1999; Uzzi, 1996, 1999), the embeddedness approach does not provide compelling analyses of the social origins of alliances and the role of social ties in constructing interorganizational networks. For instance, Gulati and Gargiulo (1999: 1439) noted that although previous research in the embeddedness approach has accounted for "why organizations behave as they do in terms of their embeddedness in social networks,", it has rarely examined "how

those networks originated." In another instance, Stuart (1998: 670) noted that "questions such as how newly founded organizations, new entrants into an industry, and firms that have not previously formed alliances gain first entry into the alliance network have been outside the purview of extant, empirical embeddedness studies." The lack of sufficient knowledge about alliance origins and alliance formation processes prevents us from comprehending exactly what organizations do prior to alliance formation to find their appropriate partners.

I therefore start this research by asking (1) how organizations reduce selection uncertainty, (2) what mechanism organizations use to do so, (3) what organizations do prior to alliance formation, and (4) how organizations form alliances. An examination of these questions requires me not only to combine pre-existing literature, but also to provide detailed and narrative descriptions of alliance formation processes.

The research context of this study is R&D alliances between biotechnology firms specializing in pharmaceutical applications. As noted above, alliances are "contractual asset pooling or resource exchange agreements between firms" (Stuart, 1998: 668). In this research, R&D alliances are those in drug discovery and development processes that comprise (1) synthesis and extraction, (2) biological screening and phramacological testing, (3) preclinical studies (toxiology and safety testing and pharmaceutical-dosage formulation and stability), (4) clinical trials phase I, (5) clinical trials phase II, and (6) clinical trials phase III. In the first two stages of the processes, scientists and researchers examine disease mechanisms and identify chemical and biological structures that cause diseases. After an initial safety test in preclinical trials, scientists and researchers clinically test not only the effectiveness but also the safety of pharmaceutical products in development. Although the number of

chemical compounds considered to be effective against the disease at issue is more than 1,000 at the beginning of the process, it is reduced to only one at the end of clinical trials phase III.

Biotechnology alliances are appropriate for the purpose of this research because previous studies reported that alliances and interorganizational collaboration are crucial for the growth and survival of biotechnology firms (i.e., Barley et al., 1992; Powell et al., 1996; Powell et al., 1999; Ryan et al., 1995; Stuart et al., 1999). In addition, biotechnology is known as a research- and knowledge-intensive industry in which procurement of, and access to, cutting-edge technology are primary concerns for the organizational leaders. Although it is certain that biotechnology is not the only industry where research and development determine organizational success (e.g., so it is also in the semiconductor industry), firms in the biotechnology industry face much greater uncertainty than those in other industries because discovery and development of new pharmaceutical products require the investment of more time and resources and demand that firms do more to ensure prospective partners' technical competence and contributions and commercial values of alliances prior to making an investment in alliances (Pharmaceutical Research and Manufacturers of America, 1999).

This study is organized as follows. In Chapter Two, I present a profile of the American biopharmaceutical industry and describe the challenges that the industry has faced since its inception. One of the important arguments in this chapter is that the industry has faced a higher degree of uncertainty because of the complexity of the technology, the substantial financial resources needed to support research and development, and the need for public acceptance of the industry. Another important characteristic of the industry is the great degree of interdependence among firms.

They form alliances to procure resources and knowledge from outside their organizational boundaries. At the end of this chapter I present some examples and quotes from the fieldwork, which is discussed in detail in Chapter Three, as to selection uncertainty and managers' concerns in forming alliances and selecting partners.

In Chapter Three I identify three mechanisms that help organizations reduce selection uncertainty on the basis of findings from my fieldwork at 25 U.S. biotechnology firms, as well as a review of previous research. Such mechanisms include (1) the relational, (2) the internal, and (3) the contextual mechanisms. The relational mechanism is the use of cultivated pre-existing and ongoing social ties in reducing selection uncertainty. The internal mechanism refers to internal capabilities and structures consisting of collaborative know-how, boundary-spanning, and technical intensity that help organizations reduce selection uncertainty. The contextual mechanism operates on the principle that prospective partners' reputations signal credibility and help the focal organization reduce selection uncertainty. I argue, however, that bounded rationality prevents organizations from completely eliminating selection uncertainty prior to alliance formation, with the result that the use and activation of the three mechanisms do not guarantee high-performing alliances. At the end of Chapter Two I discuss the theoretical contributions, implications, and limitations of findings in this chapter.

In Chapter Four, on the basis of findings in Chapter Three, I provide the model and hypotheses that explain interrelatedness among the three mechanisms and, particularly, predict organizational use of the relational mechanism. An examination of interrelatedness enables me not only to follow traditional research issues in this

field since the origination of the open-system theory, but also to explore factors that account for the selection of alliance partners and patterns of alliance formation in constructing interorganizational networks. In developing hypotheses, I employ the concept of multiplexity as a dependent variable and a proxy to the relational mechanism that depicts the extent of sharedness, closeness, and connectedness between allying organizations prior to alliance formation. I also develop hypotheses that predict associations between the relational mechanism and alliance performance. Although it has long been suggested that researchers should study the effects of the embedded nature of economic transactions on performance, little is known about the association between organizational use of pre-existing personal rapport in forming alliances and alliance performance (Gulati, 1998; Uzzi, 1996, 1999). This examination deepens our insight into the relationship between the social aspects of economic behavior and economic performance.

Study 1 in Chapters Five and Six tests hypotheses on interrelatedness. I collected data on 145 R&D alliances formed by 45 biotechnology firms publicly held in the U.S. stock markets with other U.S. publicly held biotechnology or pharmaceutical firms from 1995 to 1999. In Study 1 the unit of analysis is an alliance. I constructed the data set from several archival databases, including SEC filings in Lexis/Nexis, the Recombinant Capital Biotechnology Alliance Database, the Biography and Genealogy Database, Standard and Poor's Compustat, and so forth. In addition to the hypothesis testing in which I found indirect support for the hypothesis of a negative effect of the internal mechanism on the relational, I conducted an exploratory analysis and found another negative effect of the internal mechanism on the contextual. Two of the important findings are that (1) organizations with a higher

degree of alliance experience and collaborative know-how tend to form alliances with those with a lower degree of multiplexity and (2) organizations with a higher degree of alliance experience and collaborative know-how tend to form alliances with those with a lower reputation. These two findings suggest that collaborative know-how enables organizations to decouple their interorganizational networks from pre-existing or ongoing ties and reputation networks, so that organizations with a higher degree of collaborative know-how are more able to form alliances without the help of ties and reputation and, therefore, to construct interorganizational networks more flexibly. Contributions, implications, and limitations of these findings are discussed at the end of Chapter Six.

Study 2 in Chapters Seven and Eight tests hypotheses about alliance performance. I collected data on 46 R&D alliances formed by 23 biotechnology firms publicly held in the U.S. stock markets. In Study 2 the unit of analysis is an alliance, and the survey respondents were either CEOs (chief executive officers) or BD (business development) professionals. I also collected archival data for the respondents' firms and combined them with the original mail-survey data to test hypotheses. I employed statistical methods that do not presume a large number of observations and found no direct associations between the organizational use of pre-existing personal rapport in alliance formation and alliance performance. However, I also found that the associations became statistically significant once I incorporated several moderators into the analytical models. Contributions, implications, and limitations of these findings are discussed at the end of Chapter Eight.

Finally, I discuss relatively larger issues and contributions of this research in Chapter Nine. One of the discussions in Chapter Nine, which is particularly based on

findings in Study 1, is about the model of virtualization that potentially accounts for emerging forms of organizations. The virtual-corporation argument claims that virtual corporations form interorganizational resource networks only for short-term purposes, combining their own strength and that of others for specific projects and products, so that virtual corporations are able to create "best-of-everything" organizations. Findings of this research both pose questions to, and suggest the possibilities of, virtual corporations. On the one hand, when organizations rely on pre-existing social ties and the reputation of prospective partners in reducing selection uncertainty, construction of interorganizational networks is not as flexible as suggested in the virtual-corporation argument. On the other hand, findings in this research imply that organizations with a higher degree of collaborative know-how decrease organizational reliance on the relational and contextual mechanisms in forming alliances, so that the construction of interorganizational networks becomes more flexible as organizations develop collaborative know-how. Although a contribution of this research to the model of virtualization resides in these findings, the model itself remains a conceptual one, for this research does not incorporate into the analytical schemes a number of intraorganizational and environmental factors that facilitate processes of, and create an environment for, virtualization.

If this study shows anything of importance, it is the following. First, this research makes contributions to research on uncertainty, which has been one of the central themes since the open-system approach was introduced (Katz & Kahn, 1963). Examples of research questions that have constantly been raised include (1) how organizations manage and reduce uncertainty (Galbraith, 1974; Thompson, 1967), (2) how uncertainty shapes organizational structures and creates power-dependence

relationships within organizations (Pfeffer, 1981; Pfeffer & Salancik, 1978), (3) how management of uncertainty changes organizational boundaries and relationships among organizations (Pfeffer & Salancik, 1978; Thompson, 1978; Williamson, 1975, 1981, 1985), (4) how organizations adopt legitimated forms, structure, and strategy as a result of uncertainty management (DiMaggio & Powell, 1983; Meyer & Rowan, 1977), and (5) how environmental uncertainty influences the homogeneity and heterogeneity of organizational forms in populations of organizations (Hannan & Freeman, 1977; 1987; Stinchcombe, 1965). Stinchcombe (1990) claims that although previous literature tends to view uncertainty vaguely and not decompose it, research would become more informative and beneficial if it specified the contents of uncertainty and examined concrete organizational actions and management for different contents of uncertainty. It is certain that an examination of uncertainty as a core theme is one of the contributions of this research. One of the particular strengths of this research is its focus on a specific type of uncertainty—uncertainty in selecting alliance partners and forming alliances—and its response to Stinchcombe's arguments on the decomposition of uncertainty.

In addition, previous research tends to take one of the two major approaches to an issue of uncertainty: examining (1) intraorganizational effort to reduce uncertainty and (2) management of interorganizational relations for reducing uncertainty. Thompson (1967) claims that researchers should view the intraorganizational and interorganizational phenomena interdependently rather than separately, for focusing on only one of the approaches prevents researchers from capturing a complete portrait of organizational life and entire organizational systems for reducing uncertainty. One of the findings in this research is that organizations with higher levels of collaborative

know-how as a result of the accumulation of alliance experience have different patterns of selecting alliance partners and, thereby, constructing interorganizational networks. By demonstrating interdependence between intraorganizational and interorganizational systems that allow organizations to reduce selection uncertainty, this research responds to Thompson's claim and integrates the two approaches.

Second, this research makes contributions to the literature on the social embeddedness of economic behavior. Previous research taking the embeddedness approach tends to emphasize the importance of path-dependency and histories of shared interactions as a foundation of interorganizational networks (i.e., Larson, 1992; Gulati, 1998; Uzzi, 1996, 1998). Although this research supports the conclusion that organizations form alliances out of pre-existing personal rapport so as to reduce selection uncertainty, it also finds that organizations do not always rely upon pre-existing personal rapport and histories of interactions in constructing interorganizational networks. Social ties do not always matter. Shared histories of interactions do not always matter. Rather, this research finds that their roles are contingent on whether organizations use and activate alternative mechanisms for reducing selection uncertainty. In that sense, this research makes a contribution to pre-existing literature by adding the new knowledge that there exists variance in organizational reliance on social ties in forming alliances and by exploring factors (e.g., collaborative know-how) that account for this variance.

Third, this research contributes to research on interorganizational relations. As noted above, previous research tends to focus on transactions between organizations and collaborative (or noncollaborative) activities among organizations after alliance formation (Arino & Torre, 1998; Elg & Johansson, 1997; Grandori & Soda, 1995; Hill

& Hellriegel, 1994; Human & Provan, 1997; Inkpen & Beamish, 1997; Inkpen & Dinur, 1998; Lorenzoni & Lipparini, 1999; Ouchi & Bolton, 1988; Sobero & Schrader, 1988). Although there is an agreement that organizations need to create "win-win" situations by combining each other's strengths and overcoming each other's weaknesses (Doz & Hamel, 1998), little is known about how organizations form alliances and reduce selection uncertainty so as to create "win-win" situations. By unfolding alliance formation processes and examining organizational activities prior to alliance formation, this research proposes a concept of selection uncertainty, identifies organizational mechanisms for reducing it, and reveals the interrelatedness among them.

Fourth, one of the crucial findings in this research implies that organizations are able to learn how to select appropriate partners by accumulating alliance experience and developing collaborative know-how. In this research context, collaborative know-how means internal capabilities to scan the environment, identify alliance opportunities, collect relevant information about prospective alliance partners in assessing them, and select appropriate partners best serving their interests (Barkema et al., 1997; Powell et al., 1996; Simonin, 1997). Development of collaborative know-how enables organizations to select appropriate partners without relying upon social ties and reputation. Therefore, this research suggests that organizations with a higher degree of collaborative know-how decouple their interorganizational networks from pre-existing or ongoing social relations, and reputation or status networks, so that they are more able to extend their interorganizational networks flexibly and gain access to resources, knowledge, and information in other organizations that do not share any history of interaction and have not achieved a high reputation in organizational space.

These findings both support and extend current understanding of the embedded nature of organizations. Although this research certainly confirms the importance of pre-existing personal rapport as a foundation of interorganizational networks, it also finds variance in organizational reliance on ties and reputation. It is collaborative know-how that determines this reliance and enables organizations to identify and select appropriate partners without the help of ties and reputation.

CHAPTER TWO: HISTORIES OF UNCERTAINTY AND CHALLENGES IN THE BIOTECHNOLOGY INDUSTRY

In this chapter I provide a historical overview of the biotechnology industry with a focus on uncertainty and challenges that firms have faced. One of the points to be made is that firms have faced a higher degree of uncertainty because of technological complexity and the necessary time and financial resources for drug discovery. The growth of this industry is a result of both independent and collective efforts to reduce uncertainty so as to procure resources and obtain legitimacy. In addition to facing these issues of challenge and uncertainty, the biotechnology industry is characterized as one of the most interdependent industries, one in which firms are linked with each other through alliance formation during all phases of drug discovery processes. This chapter also explains two forms of alliances (research-outsourcing alliances and mutual-collaboration alliances) that enable firms to procure knowledge and resources outside organizational boundaries. At the end of this chapter, I present some arguments and quotes from the fieldwork, which is discussed in detail in Chapter three, on selection uncertainty and managers' concerns in selecting alliance partners.

2-1: What is Biotechnology?

Defining biotechnology is not an easy task, for it is an interdisciplinary field that encompasses microbiology, biochemistry, molecular biology, cell biology, immunology, protein engineering, enzymology, chemical engineering, food science, genetics, and electronics. The term *biotechnology* is rooted in ancient Greek *bios* ('life') and *technikos* ('skillfully made' or 'tool') (Genentech, 1999). The European Federation of Biotechnology (EFB) defines biotechnology as "the integration of

natural sciences and organisms, cells, parts thereof, and molecular analogues for products and services" (Smith, 1996: 2). The Biotechnology Industry Organization (BIO), an American biotechnology industry association, defines it more specifically: "a combination of advances in our understanding of molecular and cellular biology, plant, animal and human genetics and how the human immune system fights disease" (The Biotechnology Industry Organization, 1999). Genentech (1999), a giant biotechnology firm, defines it with an emphasis on technology: "the use of a living organism to make a product or run a process" and "genetic engineering and recombinant DNA technology." Pharmaceutical Research and Manufacturers of America (1999), another American industry association, provides classifications of technologies in biotechnology and three different meanings of biotechnology:

1. Traditional biotechnology uses living organisms (or parts thereof) to produce or modify chemical compounds.
2. Gene technology, or genetic engineering, uses DNA's properties to analyze and modify the genetic information.
3. Reproduction biology means traditional breeding techniques, in-vitro fertilization, and cloning of organisms.

It follows from these definitions that I define biotechnology as technology to optimize particular characteristics sought in an organism by advancing and applying genetics and molecular biology.

Biotechnology has been applied to miscellaneous industrial fields, including (1) human and animal food production, (2) provision of chemical feed stocks, (3) alternative energy sources, (4) waste recycling, (5) pollution control, (6) agriculture and forestry, (7) medicine and pharmaceuticals, and (8) veterinary sciences. Among

these applications, medicine and pharmaceutical fields have the greatest industrial impact on American society, for applications of biotechnology to these fields are estimated to account for about 74% of U.S. biotechnology product sales in 1998 (The Biotechnology Industry Organization, 1999). The pharmaceutical and human therapeutics applications encompass (1) therapeutic products (hormones, regulatory protein, antibiotics), (2) prenatal diagnosis of genetic diseases, (3) vaccines, (4) immunodiagnostic and DNA probes for application to diseases, and (5) genetic therapy.

An example of a biotechnology product is EPO (Erthropoeitin). Researchers at Amgen used gene-splicing techniques in the early 1980s to produce large quantities of EPO, which is a natural protein that stimulates and facilitates the production of red blood cells. The potential patients are some 120,000 people in the U.S. who suffer from severe anemia from kidney malfunction. EPO saves patients from relying upon expensive and potentially risky blood transfusions.

It must be noted that pharmaceutical applications of biotechnology have made boundaries more obscure between the pharmaceutical and biotechnology industries. In essence, pharmaceutical firms use inorganic chemicals to develop new drug compounds, while the principal materials used by biotechnology firms for drug discovery and development are naturally occurring substances from the human body and organic material from plants and animals. However, results of pharmaceutical firms' recent efforts to enter the biotechnology markets through either in-house development or alliances with biotechnology firms have blurred the boundaries between them with the result that *biopharmaceutical* has now become a common term in the industries. In the scope of this research, however, I exclude the large

established pharmaceutical and chemical firms listed in Fortune 500 *Pharmaceutical and Chemical Firms* and Standard & Poor's *500 Pharmaceutical Firms* (i.e., American Home Products, Bristol-Myers Squibb, DuPont, Merck, Monsanto, and the like).

2-2: Technological Challenges and Principles of Biotechnology

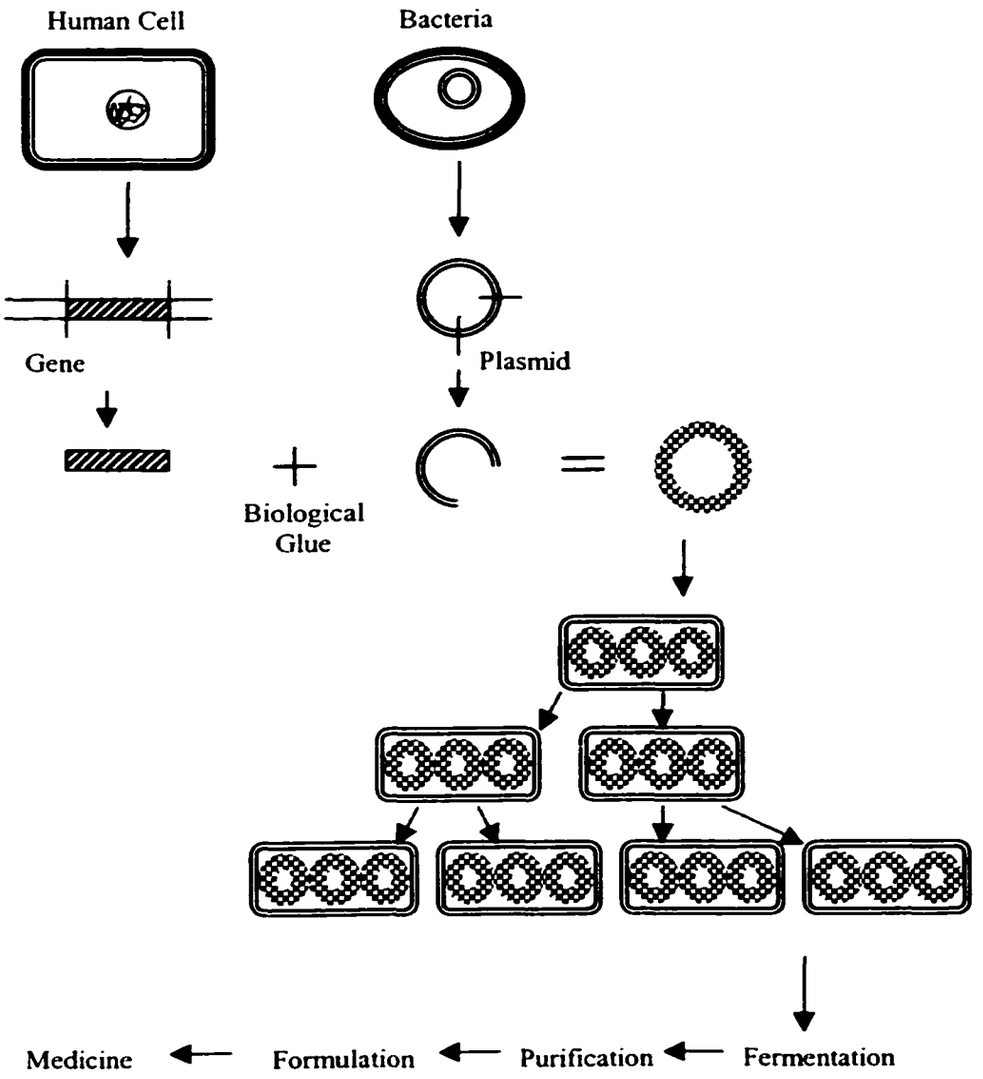
The biotechnology (or biopharmaceutical) industry is a knowledge-intensive and research-driven industry in which a firm's strength in research and development determines its growth and, ultimately, survival (Ryan et al., 1995). Firms competing with each other in finding new pharmaceutical products and therapeutic methods to treat diseases face a high degree of uncertainty in respect to new technology and products. It is a challenge for all of them to reveal unknown disease mechanisms, find new effective biological treatments, develop intellectual property, and commercialize their science. All the biotechnological methods can be traced back to two innovative findings that allow scientists to manipulate DNA.

All living things are made of cells that are programmed by DNA (deoxyribonucleic acid), which consists of four nucleotides including adenine (A), guanine (G), thymine (T), and cytosine (C), as well as sugar and a phosphate. DNA has two unique properties. First, it contains construction plans for the components of living organisms. It tells individual cells how to develop into cells for eyes, blood, muscles, skin, and so forth. The second property is that DNA instructs different cells to produce specific proteins whose interactions enable living processes such as metabolism, growth, and movement. Also, DNA gives instructions for the creation of other substances, such as enzymes that facilitate chemical reactions. The outcome of DNA's instructions enables host organisms to fight diseases, predators, and other

threats. This basic function of DNA suggests that disease is a result of missing or malfunctioning proteins that disable appropriate living processes, biochemical reactions, and antivirus activities.

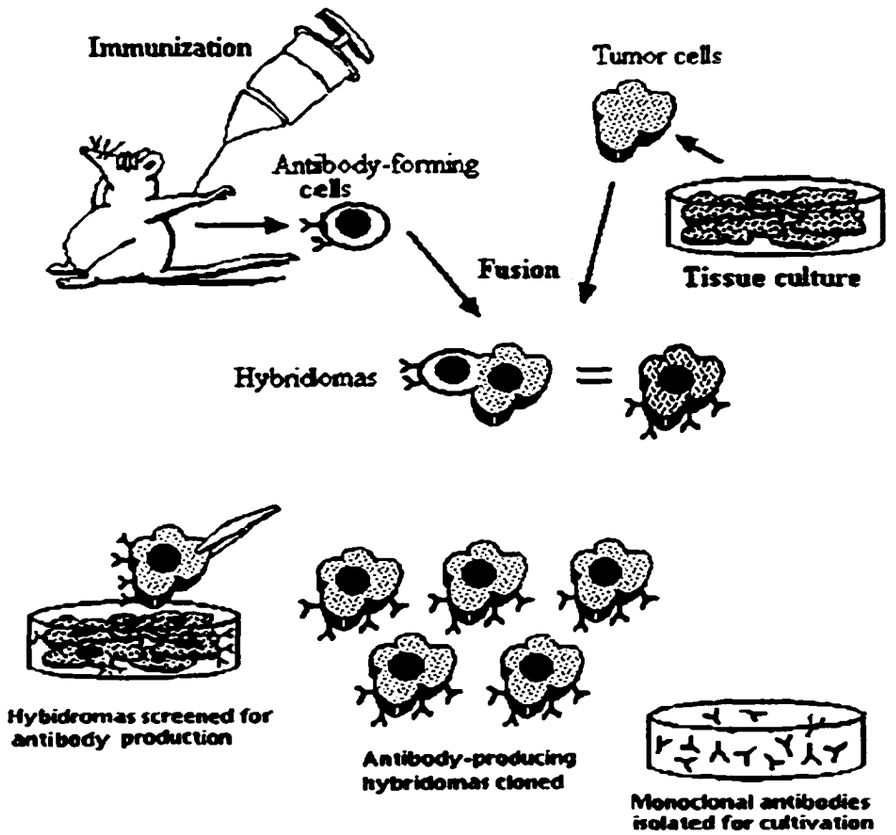
Recombinant DNA (rDNA), a basic technique in biotechnology, is built upon this basic principle, which was developed by Herbert Boyer, at the University of California, San Francisco. and Stanley N. Cohen, at Stanford University, in 1973. First, by identifying, locating, and understanding gene structures and the roles of related proteins, biotechnologists are able to point out how to prevent and cure malfunctions of proteins produced by the genes in DNA. Then, enzymes play the role of scissors that isolate individual genes. Two isolated parts of genes (i.e., one from human cells and the other from bacteria) are glued together by biological glues and then inserted into a cell. Finally, this cell produces a desired protein as a cell factory that is fermented, purified, and formed into medicine. Figure 2-1 demonstrates an example of rDNA for human insulin. A part of human DNA is isolated from a cell and inserted into the genome of a bacterium. The bacterial cell reads the language of the human gene and produces human insulin. rDNA enables biotechnologists to directly manipulate the DNA of cells of different types of organisms and create new combinations of characteristics and abilities not previously known to be present.

Other important technological principles are protoplast and cell-fusion technologies, which are typically used for creating a monoclonal antibody, a protein produced by certain types of white blood cells to fight diseases and foreign proteins. Genentech (1999) presents the following basic processes of the technologies (see also Figure 2-2):



Source: Pharmaceutical Research and Manufacturers of America (1999)

Figure 2-1: Recombinant DNA: A Case of Human Insulin



Monoclonal Antibody Production

Source: Genentech (1999) (http://www.accessexcellence.org/AB/GG/monoclonal.html)

Figure 2-2: Protoplast and Cell Fusion Technologies

> We can obtain cells that produce antibodies naturally; we also have available a class of cells that can grow continually in cell culture. If we form a hybrid that combines the characteristic of "immortality" with the ability to produce the desired substance, we would have, in effect, a factory to produce antibodies that worked around the clock. In monoclonal antibody technology, tumor cells that can replicate endlessly are fused with mammalian cells that produce an antibody. The result of this cell fusion is a "hybridoma," which will continually produce antibodies.

Hybridomas were first created by Cesar Milstein and George Kohler in the Medical Research Council's Laboratory of Molecular Biology in Cambridge in 1975.

There are primarily four phases in chemistry-based drug discovery and development processes: (1) early discovery (synthesis and extraction), (2) screening and pharmacological testing, (3) preclinical studies (toxiology and safety testing and pharmaceutical-dosage formulation and stability), and (4) clinical trials (Pharmaceutical Research and Manufacturers of America, 1999). In general, diseases are a result of missing or malfunctioning genes that prevent the creation of appropriate proteins for living processes, biochemical reactions, and antivirus activities.

The first phase is aimed at advancing knowledge of disease mechanisms and validating targets. The second phase is aimed at discovering thousands of potential chemical compounds for targets, screening them, and identifying a few hundred compounds that potentially recover the malfunction of proteins. After the chemical compounds are transformed into drug forms and the safety tests are run, clinical trials are conducted that consist of three phases: (1) testing on a small number of healthy people to check safety, (2) testing on patients suffering from the targeted disease to check effectiveness, and (3) employing larger samples and conducting research with placebo control to check safety and efficacy. Clinical trials are aimed at identifying

clinically the most-effective compound that works for targets as well as meets the safety standards.

Biology-based drug discovery and development processes also start with the identification of a therapeutic protein that causes a particular disease. After advancing an understanding of causal mechanisms of a disease, its symptoms, and its complications, researchers produce large quantities of normal proteins with the help of genetic engineering. Scientists isolate the genetic sequences, or genes, that instruct cell production of specific proteins and splice them into the genes of the microorganism or cell. Researchers reproduce the engineered genes with nutrition (i.e., sugar) and transform them into drug forms for preclinical and clinical trials.

In both cases the outcome of the clinical trials is submitted to the FDA's (Food and Drug Administration) Center for Biologics Evaluation and Research (CBER) and Center for Drug Evaluation and Research (CDER) for their approval. According to a report by the U.S. Office of Technology Assessment, it can cost from $200 million to $350 million and take from seven to twelve years for a product to move through development and FDA approval. The required time and investment of financial resources for drug discovery and development increase uncertainty as to technology and, particularly, the commercial success of scientific findings and products. An example I found in fieldwork[1] demonstrates the technological challenge that firms in the industry always face. Two firms formed an alliance and conducted joint research projects. Although they obtained some scientifically interesting findings, it turned out that those findings did not have any implications for the therapeutic fields in which the two firms were working and therfore had no commercial value. Finding something

[1] Details of the methodology of the fieldwork are available in Chapter 3.

scientifically valuable is not easy; likewise, finding something commercially valuable is not easy. These dual difficulties and the nature of the industry, as well as the time and financial resources invested, pose a high degree of uncertainty and challenge to biotechnology firms.

2-3: Growth and History of the Biotechnology Industry

The growth and history of the biotechnology industry are, in a sense, those of independent and collective efforts to procure financial resources, to reduce uncertainty associated with the intellectual property of biotechnological products and findings, and to reduce uncertainty pertaining to appropriate business conduct in order to increase the legitimacy of the industry. Given the great size of the financial resources required for drug discovery and development, procurement of financial resources has been one of the major concerns in the industry (Standard & Poor's, 1999). In addition, the availability of those resources, as discussed below, has changed industrial structures from those consisting of independent firms possessing not only research and development, but also marketing and distribution capabilities, to those consisting of firms dedicated to specific phases of drug-discovery processes or therapeutic areas with a high degree of interdependence among firms for commercialization. These three major elements—(1) financial resources, (2) intellectual property, and (3) legitimacy—are indeed interrelated in the sense that an entitlement to intellectual property for biotechnological products and legitimization of the industry have triggered and increased investors' attention to biotechnology as one of the profitable high-tech areas, rather than as just a scientific field, and facilitated the inflow of financial resources.

The history of biotechnology can actually be traced to ancient and traditional fermentation processes such as the brewing of beer and the manufacture of bread, cheese, yogurt, wine, and vinegar. It is evident, however, that modern biotechnology had its beginning in the research on antibiotics by Alexander Fleming in 1928 and the first description of DNA structures by James D. Watson and Francis Crick in 1953. Following these scientific contributions, two major technological breakthroughs occurred in the 1970s: (1) the creation of hybridomas in 1973 and (2) the development of rDNA in 1975. Although these scientific developments were necessary conditions for the growth of the biotechnology industry, we would be unable to observe that growth without the occurrence of three social events: (1) the change of the Employee Retirement Income Security Act of 1974 (ERISA) in 1978, (2) patent protection granted by the U.S. Supreme Court in 1980, and (3) the Asilomar conference in 1975 (Bud, 1997; Kelves, 1997; Ryan et al., 1995).

First, in 1978 the U.S. Department of Labor released a proposed regulation on its administration of pension-fund investment. A new guideline, named the Prudent Man Rule, suggested that fund managers are liable for the results of imprudent investments. This regulatory change increased the partial dependence of fund managers on venture capitalists with specialized knowledge to manage their own funds (Ryan et al., 1995). Venture capitalists, who had enjoyed significant success in investing in the semiconductor and computer industries before the late 1970s, opened the gate and started the flow of financial resources into the biotechnology industry as another profitable area. Venture capitalists became interested in biotechnology because it is not only another high-tech field, but also profitable.

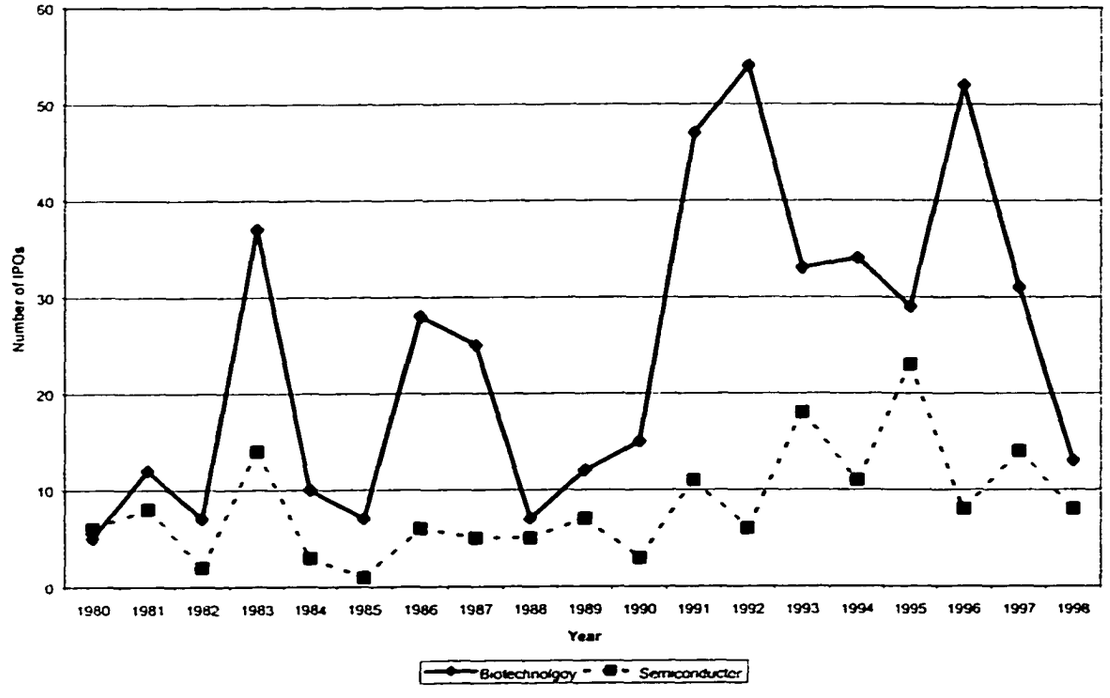
The second social event accounts for venture capitalists' considering biotechnology to be seeds of capital. In 1976 the U.S. Patent Office granted rights to Boyer and Cohen's rDNA technique. In the Diamond *vs.* Chakrabarty patent case in 1980, the U.S. Supreme Court ruled that genetically engineered life forms were patentable. Those patent policies implied that patents would secure intellectual assets, that biotechnology would be a profitable area of business, and that investment in research and development would be returned. Another impact of the patent policies was that small entrepreneurial biotechnology firms were able to collaborate with each other and other giant pharmaceutical firms without fear of losing intellectual assets.

Third, the growth of industry requires legitimacy and acceptance by the public. One characteristic of the biotechnology industry is that it always faces ethical challenges from the public and thus needs to legitimize and justify its presence. A recent hostile public reaction to the birth of Dolly (a cloned ewe) at Roslin Institute in 1996 demonstrated that fact. The public views clone technology as unethical and challenging to the rule of nature, demanding the establishment of "bioethics." Applications of biotechnology are indeed regulated by law in many countries. Without efforts to establish legitimation and justification by biotechnologists and government, biotechnology would not exist. A first collective effort at justification was made at a conference held at Asilomar, California, in February 1975, where biotechnologists proposed a voluntary moratorium until they could form a professional consensus on safety and prospects. This attempt was aimed not only at avoiding over-regulation by the government, but also at claiming safety and a well-established ethic in the industry. Along with the voluntary moratorium, the U.S. government regulations (i.e., the National Institutes of Health regulations in 1976) and the

founding of regulatory organizations (i.e., the NIH Recombinant DNA Advisory Committee) defined the extent of industrial applications, alleviated public concerns about safety, and presented opportunities to educate the public about biotechnology through a series of congressional debates and hearings.

The reality of how biotechnology started to grow as an industry is more complex than the simple description above. There are many other factors and complicated interactions between social actors and events. However, such historical analysis is available elsewhere (e.g., Bud, 1997; Ryan et al., 1995; Werth, 1995) and beyond the purposes of this study, so it is sufficient here to emphasize that the development of biotechnology is not just a result of the autonomous progress of biology independent of social contexts. The growth of the industry has been interwoven with collective efforts and social events that allowed it to reduce uncertainty and increase legitimacy to the point where it could signal to the environment that biotechnology is not only science but also business.

Another symbolic event in the emergence of biotechnology as a "business sector" was the initial public offerings (IPOs) of Genentech on October 14, 1980. IPOs, often used as an indicator of entrepreneurship, mean that firms start to sell equity securities (i.e., common and preferred stock) to the public, procure capital from the unlimited number of investors, and share their ownership with them. Genentech's initial offering price of $35 rapidly increased to $89 within an hour and set a record on Wall Street. Although this symbolic event attracted investors' interests to biotechnology, the number of IPOs has not increased consistently. In Figure 2-3, I plot the number of IPOs in the



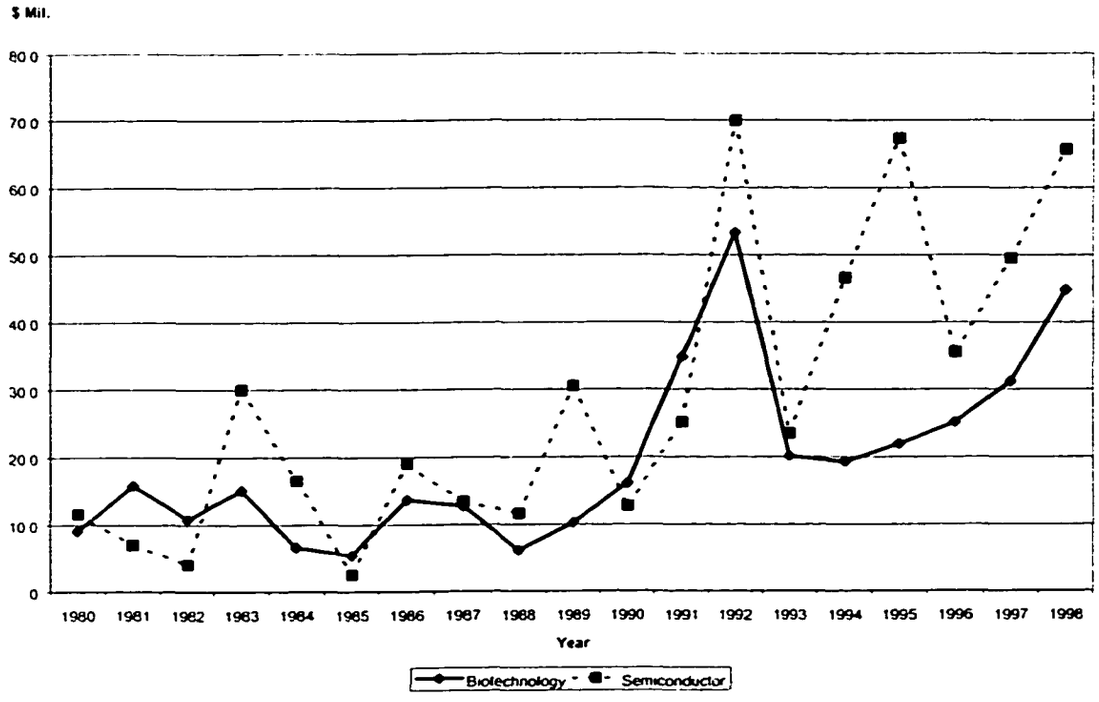
(Source: SDC)

Figure 2-3: Number of IPOs in the Biotechnology and Semiconductor Industries

biotechnology and semiconductor industries from 1980 to 1998 (obtained from the SDC Securities Database (SDC)). It is certain that the number of biotechnology IPOs is greater than that of semiconductor IPOs during that period. However, what we can observe is a 3-5-year cycle of increase in the number of biotechnology IPOs instead of constant growth. Among various factors that cause this tide, such as long-term market forecasts and changes of capital pools available for biotechnology firms, Ernst & Young (1999) point out a close link between the number of IPOs and the percentage of early-stage pre-IPO firms: a greater number of IPOs in time $t-1$ will result in a smaller number of pre-IPO firms at time t.

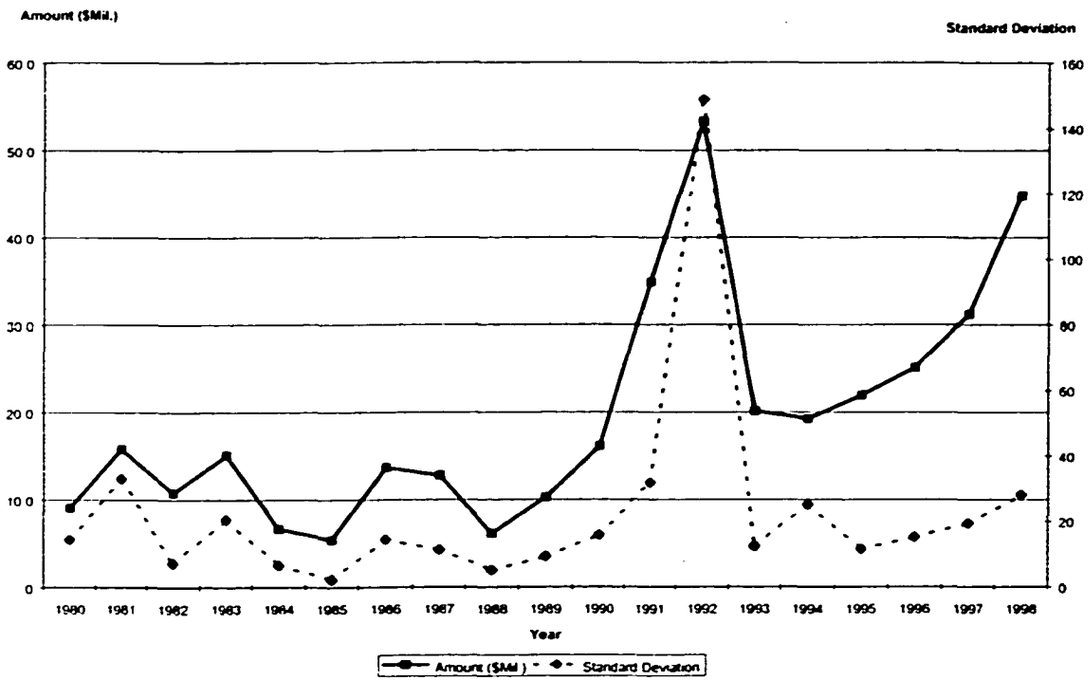
Another indicator of biotechnology growth in the IPO market is the amount of capital that firms procure through IPOs, computed by multiplying an offer price by the number of shares offered. Figure 2-4 shows the amount per firm from 1980 to 1998 in the biotechnology and semiconductor industries. Figure 2-5 illustrates the amount per firm and its standard deviation in biotechnology. First, firms in both industries that went public recently procure more capital through IPOs than did those in the 1980s. Biotechnology firms, as well as semiconductor firms, now play a more significant role in the IPO market and are able to obtain more capital through IPOs.

Second, the standard deviation of the biotechnology firms' average amount raised is relatively stable except in 1992. The trend of an increasing presence of biotechnology firms in the IPO market is not caused by a few outstanding players procuring an unusual



(Source: SDC)

Figure 2-4: Amount Raised per Firm from 1980 to 1998 in the Biotechnology and Semiconductor Industries



(Source: SDC)

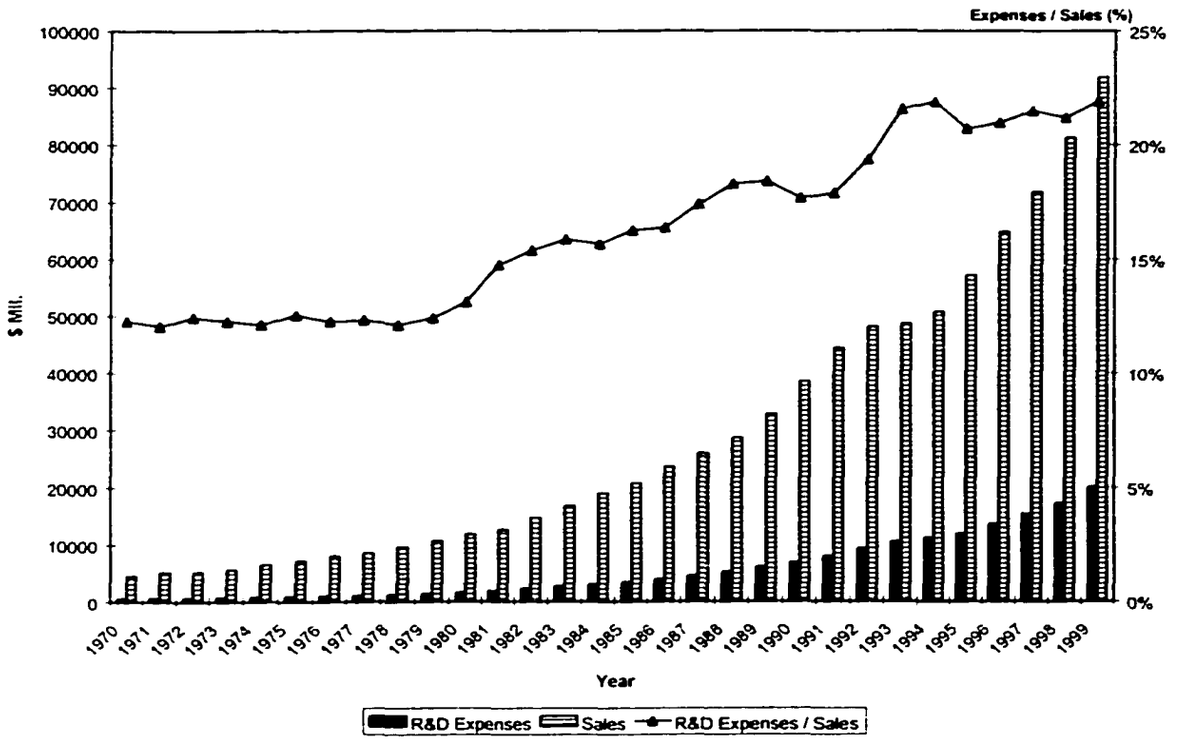
Figure 2-5: Amount Raised per Firm and Its Standard Deviation from 1980 to 1998 in the Biotechnology Industry

amount of capital through IPOs and pulling the average, but by each IPO firm now obtaining greater capital than before. The remarkably high score in 1992 is due to Wellcome PLC, whose amount raised was $1067.5 million.

Third, the increasing amount raised also indicates that biotechnology firms recently needed to procure more capital for running a business. The most obvious factor that increased the need for capital was R&D expenditure. Figure 2-6 is a result of the annual survey by Pharmaceutical Research and Manufacturers of America, which has about 100 member companies. Along with the growth of sales, their R&D expenditures have consistently increased. Firms invested on average about 22% of their sales in R&D in 1999.

Figure 2-6 also shows rapid sales increases in the pharmaceutical industry in the last three decades: about a 2,000% increase, from $4,553 million in 1970 to $91,823 million in 1999. During this growth, biotechnology has been applied to various pharmaceutical research and development processes such as finding means to combat cancer, infectious diseases, AIDS, heart disease, and so forth (see also Table 2-1). There are 410 biotechnology drug products and vaccines currently under human clinical trial and hundreds more early-stage projects in the United States. The Biotechnology Industry Organization (1999) estimated that over 200 million people in the world have been helped by the more than 80 biotechnology products approved by the FDA.

Table 2-1 shows that one of the hottest pharmaceutical products under development is cancer related. Cancer is caused by the uncontrolled growth and spread of abnormal cells. Genetic mutations or defects cause disruptions of the normal cellular growth-control mechanisms so that excessively multiplied cells result



(Source: Pharmaceutical Research and Manufactures of America (1999))
Note: Data for 1998 and 1999 are based on estimations.

Figure 2-6: Domestic Sales and R&D Expenditures of Pharmaceutical Firms from 1970 to 1999

Table 2-1: Biotechnology Medicines in Development by Therapeutic Categories

AIDS / HIV infection related disorders	29
Autoimmune disorders	19
Blood disorders	8
Cancer / related conditions	151
Diabetes / related disorders	13
Digestive disorders	9
Eye conditions	3
Genetic disorders	10
Growth disorders	4
Heart disease	28
Infectious diseases	36
Infertility	4
Neurologic disorder	26
Respiratory diseases	20
Skin disorders	14
Transplantation	14
Other diseases	22

Source: Pharmaceutical Research and Manufacturers of America (1999)

in the formation of a tumor. Tumors turn especially deadly when cancer cells metastasize to internal organs or spread throughout the body. There are currently four therapeutic methods available to cancer patients: (1) surgery, (2) radiation, (3) chemotherapy, and (4) immunotherapy. Although immunotherapy, which is also referred to as biotherapy, is the least-popular method, a number of biopharmaceutical products for it are under development and clinical trial. Immunotherapy is built upon a principle of immune defense systems: using the body's natural immune system.

Human beings have their own immune defense systems. B-cells, a class of blood cell, either neutralize the microorganism's' ability to cause disease or trigger other molecules and cells to destroy them. This process is termed *antibody response,* or *antibody immunity.* T-cells, a type of white blood cell, attach themselves to infected cells and destroy them. This process is named *cellular immunity.* There is also another process of the immune defense systems, named *acquired immunity*: the systems memorize the identify of the foreign invaders and deactivate them if they appear again.

Despite these organized processes inside our bodies, cancer occurs. One reason is that the similarity of cancer cells to normal cells makes it difficult for the immune defense system to recognize the cancer cells. The other reason is that a response of the immune defense system is not strong enough to destroy and kill the cancer cells. Interleukin-2 is one of the proteins that stimulate and signal the immune system to activate certain lymphocytes, specific T-cells, that target and kill the cancer cells.

In 1992, Chiron, one of the largest U.S. biotechnology firms, obtained FDA approval for its product, Proleukin. It uses a recombinant form of Interleukin-2 that is

effective against metastatic kidney cancer and metastatic melanoma, an advanced form of skin cancer. Proleukin is injected into cancer patients to stimulate the growth and activity of cancer-killing cells.

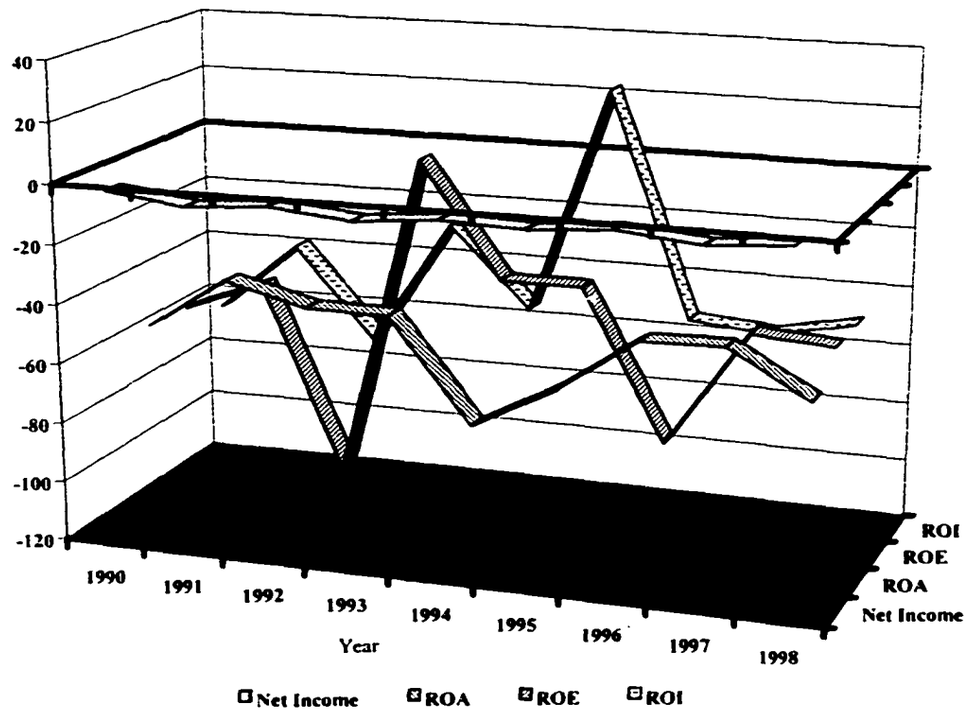
Since then, a number of immunotherapy products have been developed and clinically tested. For instance, tumor-cell vaccines are one of the methods under clinical trial. The vaccines use cancer cells obtained either from the patient being treated or from another patient. The tumor cells are killed before the injection to stop their growth. Antigens on the tumor cells survive, however, so they can stimulate a specific immune-system response to kill the cancer cells. Another example of emerging therapeutic methods is DNA vaccines. By using recombinant DNA, scientists inject bits of DNA that produce certain antigens to fight the cancer cells. DNA vaccines are expected to be more effective than tumor-cell vaccines because they produce fewer antibodies that would otherwise kill the antigens that are supposed to eliminate the cancer cells.

In addition to scientific development, financial opportunities available to biotechnology firms, and the collective efforts to obtain justification and legitimation noted above, there are two other factors that help the industry grow further. The first factor is aging society. WHO (World Health Organization) forecasts that the over-65 population will increase from 380 million in 1997 to more than 800 million by 2025. This demographic factor enhances the role of, and the reliance on, pharmaceuticals and drugs in society.

The second factor is the changes in the FDA's drug-approval processes. The Prescription Drug Use Fee Act (PFUFA) in 1992 and the FDA Modernization Act of 1997 allow the FDA to use funds pooled by commercial pharmaceutical firms to speed

up its approval processes. The effects of the enactment have been striking: while it took about 27.9 months for the FDA to approve new drugs in 1986, the time now required is about 12.8 months (FDA, 1999). The time for approving new molecular entities shortened from 34.1 months to 11.7 months. It is estimated by Pharmaceutical Research and Manufacturers of America (1999) that total development time varies, but on average it takes 12 to 15 years from preclinical development to marketing approval. However, since this estimation does not include the early-discovery phase, the actual time required for the entire drug-development processe should be more than 15 years.

The necessary long-term perspective and the large financial investment in the drug-discovery processes suggest another imprtant feature of the biotechnology industry: most firms today cannot deliver financial values and make any profit on commercialized products. Figure 2-7 illustrates changes of the publicly-held biotechnology firms' financial performance from 1990 to 1998 measured by net income, return on assets (ROA), return on equity (ROE), and return on investment (ROI). Because the data, obtained from Standard & Poor's Compustat, consist only of the firms surviving at the end of 1998, the graph overstates positive performance. However, regardless of some fluctuations that push the performance indicators above U.S. $ zero, this graph indicates the firms' overall serious financial situation as well as investors' patience. This situation also relates to alliances and interorganizational collaboration in the biotechnology industry, which is discussed in the next section.



Note 1: The data were collected from Standard & Poor's Compstat.
Note 2: The data are based upon the publicly-held biotechnology firms surviving at the end of 1998. Because firms that exited during this period were not included, the data overstate the performance. The number of firms examined varies from 123 in 1990 to 297 in 1998.

Figure 2-7: Performance of the Publicly-held Biotechnology Firms, 1990-1998

2-4: R&D Alliances in the Biotechnology Industry

In this research I define R&D alliances as those occurring at any phase of the drug-discovery and development processes. In practice I focus on two types of R&D alliances: (1) research outsourcing and (2) mutual collaboration. Research-outsourcing alliances mean that a firm contracts out one (or some) of its scientific and research projects to another firm, making cash payments or equity purchases. The appearance of research-outsourcing alliances demonstrates that alliance formation in the biotechnology industry is a result of not only the search for knowledge and technology outside organizational boundaries, but also of the dynamism of the industry structures and boundary-blending activities of pharmaceutical and biotechnology firms (Flingstein, 1995; Hannan & Freeman, 1989).

Industry and environment since 1995 look quite different from those before that year. Investors have become more interested in the dot-com and Internet industries and relatively less interested in biotechnology. This trend is clearly revealed in the number of biotechnology IPOs in Figure 2-3, above. Except in 1996, the IPO number has not been increasing, in contradiction to investors' predictions made in the early 1990s (Standard & Poor's, 1998). In addition, Figure 2-5 shows that although the IPO number has not been increasing, the amount of capital raised through the IPOs has been increasing in the later 1990s. This suggests that investors have become more cautious and selective in investing money in biotechnology firms. The financial pressures have changed organizational goals as well as industry structures. Standard & Poor's (1995) reported that

> As the industry took shape in the 1980s, the dream of most biotechnology firms was to develop, manufacture, and market their own therapeutics. Only a handful of companies have attained that goal: Amgen, Chiron, and Genzyme are among the favored few. Yesterday's dreams have yielded to today's hard truth – with their primary technologies still in clinical trials, the goal of most biotechnologys is to simply stay alive.

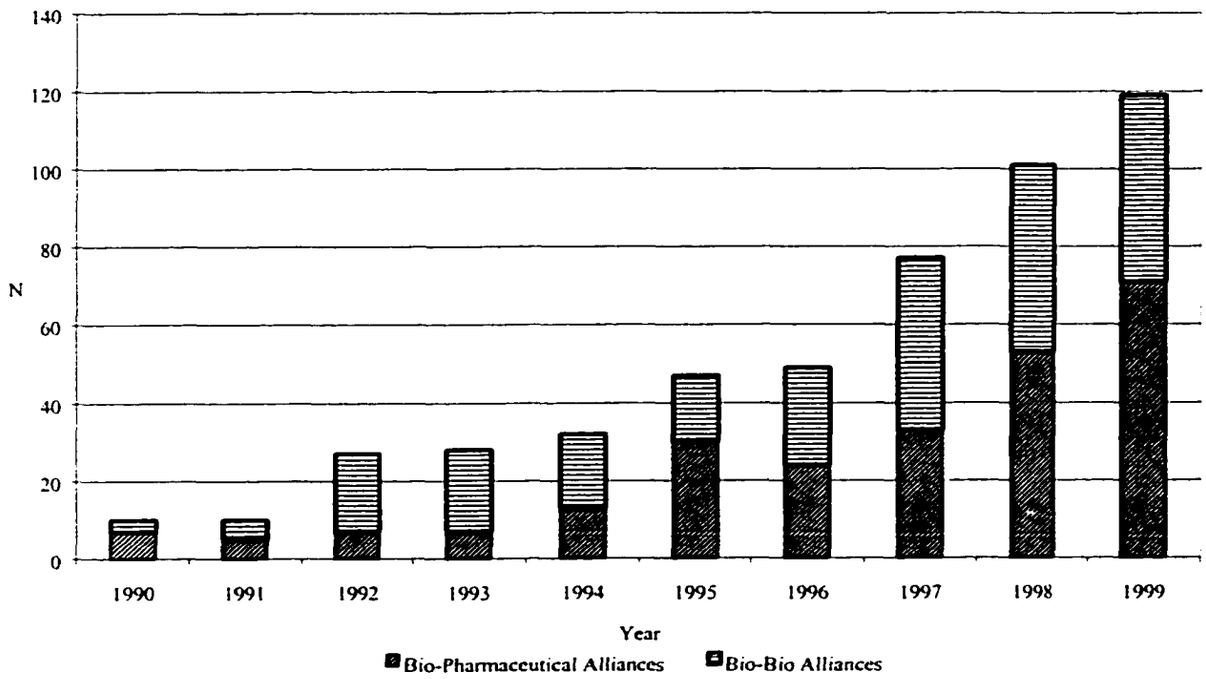
The financial pressures have increased biotechnology firms' interest in seeking capital from established and large pharmaceutical firms by forming alliances and conducting research projects for them on the basis of their strength in biology and molecular science. In other words, biotechnology firms have shifted their strategy from functioning as stand-alone companies with their own product lines to acting as organizations that sell their technology and knowledge by conducting contracted-out research projects.

The biotechnology firms' new view is matched with the pharmaceutical firms' quest for biotechnology. Whereas established pharmaceutical and chemical firms, whose researchers were not trained in biotechnology, had not been interested and active in biotechnology research and products, they shifted their approach because of the slowdown in industry growth in the early 1990s. The decreased growth rate was attributable to (1) the Clinton administration's new health-care policies that placed pressure on the high price of drugs, (2) expiration of patents, (3) technological obsolescence, (4) the maturity of ethical and over-the-counter drug markets, and (5) the rising cost of direct-to-consumer advertising. The slowdown strengthened established pharmaceutical firms' motivation to enter a new product market, biotechnology products, and to engage in collaboration with biotechnology firms to acquire less risky, more cost-efficient, and faster access to cutting-edge

biotechnological expertise than development of their own in-house research capabilities would provide.

An alliance between Procter & Gamble (P&G) and Regeneron, formed in May, 1997, serves as a good example of a research-outsourcing alliance. The alliance, agreed upon in a 10-year contract, is aimed at discovering, developing, and commercializing pharmaceutical products in cardiovascular, bone, muscle, arthritis, and other diseases. Over the first 5 years of the agreement, P&G provides $135 million, which includes a $60 million equity purchase to support Regeneron and its research programs. In the second five years, the firms will equally share all related research expenses. As a result of the agreement, P&G has rights to Regeneron's pre-existing technology in the therapeutic fields noted above and will have rights to new technology developed from the alliance.

It is not correct to claim that there was no matched interest in biopharmaceutical alliances involving the outsourcing of research projects before the mid-1990s (Barley et al., 1992; Powell & Bradely, 1992). Figure 2-8, obtained from ReCap (Recombinant Capital Alliance Database), illustrates the number of R&D biotechnology-pharmaceutical and biotechnology-biotechnology alliances from 1990 to 1999. Although there were some biotechnology-pharmaceutical alliances in the early 1990s, the number itself and the proportion of such alliances in the industries have been increasing since then. It follows that (1) the biotechnology industry has changed since around 1995 because of the change in industrial structures and the entrance of pharmaceutical firms into the industry, (2) the industrial boundaries



Note 1: The data were collected from ReCap.
Note 2: Because ReCap only contains alliance data of surviving organizations, the number is underestimated.

Figure 2-8:Number of Biotechnology and Pharmaceutical Alliances

between biotechnology and pharmaceutical have become more obscure, and, more relative to this research, (3) R&D collaboration and alliances between biotechnology and pharmaceutical firms have become more visible.

Another form of R&D alliance, usually between biotechnology firms, is mutual-collaboration alliances. In this form of alliance, researchers and scientists from different organizations create joint research teams in which they mutually exchange their own technological strength and share scientific information for drug discovery and development. Biotechnology firms are typically founded upon unique technology and do not have the full set of skills required for the entire drug-discovery and development process. Organizations seek complementarity of technological strength by combining different skill and knowledge sets through alliances (Ryan et al, 1995).

An alliance between Progenics and Pharmacopeia is an example of the mutual-collaboration alliance. This collaboration was begun in June 1998 to discover small-molecule HIV therapeutics that block the attachment of the virus to its primary cellular receptor, called CD4. Such inhibitors are thought to be effective in slowing or stopping viral infection and disease. The alliance combines Progenics's expertise in HIV biology with Pharmacopeia's leadership in small-molecule drug discovery. Pharmacopeia contributes its own combinatorial chemistry libraries of small-molecule drug candidates and medicinal-chemistry expertise, while Progenics provides its own technologies for the high-throughput screening of compounds. In other words, Progenics conducts the screening of potential compounds identified by Pharmacopeia, whereby the two organizations create sets of drug candidates that would be CD4.

As noted above, one of the motives for firms to collaborate is to share risks for costly projects that exceed a single firm's affordability (Kogut, 1988; Oliver, 1990). Research consortiums and multifirm industry collaboration are an important organizational arrangement to pool large-scale resources and develop technological platforms (Ouchi & Bollon, 1988). The most representative example is SEMATECH (Semiconductor Manufacturing Technology), a research consortium formed by the collaborative efforts of the nation's leading companies in partnership with government (Browning, Beyer, & Shelter, 1995; Spencer & Grindely, 1993). The consortium was established in 1987, primarily by major members of the Semiconductor Industry Association, to respond to the increasing competitiveness of Japanese semiconductor firms. The member firms pool financial and human resources to conduct projects that can potentially deliver values to the entire American semiconductor industry.

This industry-level collaboration is also found in the biotechnology industry. Single Nucleotide Polymorphisms Consortium Ltd. (SNP) was established in April 1999. The two-year, $45 million initiative to create a high-quality map of genetic markers is funded by the Wellcome Trust and 10 pharmaceutical companies: AstraZeneca PLC, Bayer AG, Bristol-Myers Squibb Company, F. Hoffmann-La Roche, Glaxo Wellcome PLC, Hoechst Marion Roussel AG, Novartis, Pfizer Inc., Searle, and SmithKlineBeecham PLC. The purpose of this consortium is to provide public genomic data: "its mission is to develop up to 300,000 SNPs (single nucleotide polimorphisms, DNA sequence variations) distributed evenly throughout the human genome and to make the information related to these SNPs available to the public without intellectual property restrictions" (Single Nucleotide Polymorphisms Consortium, 2000). The construction of genomic databases is useful for identifying

specific genes involved in both common and rare diseases, so they not only facilitate the discovery of new medicines, but also help the development of gene therapy.

As discussed in Ouchi and Bollon (1988), industry-level collaboration is effective and beneficial because the genome research projects require a large pool of financial resources and create knowledge that provides technological platforms and de facto standards of technology. In addition, collaboration reduces proprietary restrictions on the gene information with the result that the entire industry is able to use the industry-wide knowledge without the heavy burdens of royalties and licensing fees.

Finding appropriate partners is one of the most crucial activities in forming and running alliances, because the appropriateness of the match determines the effectiveness of an alliance (Simonin, 1997). A comment by a BD executive in the fieldwork demonstrates the importance of selection uncertainty:

> We select partners who can give us resources. Financial resources are an important part of that, particularly for our company. We are looking for them to provide, depending on partners and products, either (1) access to market and skills sets – in the form of chemistry, clinical, regulatory matters, manufactures, marketing complementary products, and capacity; (2) an area in which we do not necessarily make our own investment; or (3) aspects of research and development of pharmaceutical products or markets where we do not have skills or do not want to make investment to build the skills.

Although he emphasizes the importance of resources and knowledge that partners can provide to his firm, another BD executive in a different firm, which is large and successful, stresses linkages and connections between alliance formation and achievement of strategic objectives.

> (The most important point in selecting alliance partners) is knowing what we want, having our strategic objectives in mind, knowing what kind of therapeutic areas we are interested in, stage of development or projects we are interested in, and what would fit with what we do as an organization versus what we do not. So, we have particular capabilities as well as sales and marketing. Some products would not fit our capabilities. It is a waste of time to analyze products that we could not commercialize.

Given that, by forming alliances, firms attempt to gain access to knowledge and resources that they do not possess currently, it is reasonable to claim that alliances do not help their resource and knowledge procurement processes when partners do not possess them either. In addition, if partners with resources and knowledge on target withhold them, the alliances do not have any actual influence on firms. Furthermore, if the outcomes of alliances are not directly linked with firms' performance, alliance formation does not contribute to their financial performance and goal achievement. Even though the knowledge-intensive character of this industry may highlight the importance of selection uncertainty in respect to partners' technical competence, it is also important for firms to ensure that partners are willing to share their resources and knowledge and make a proactive effort to succeed in the alliance, as well as to contribute to the attainment of organizational goals. One of the interviewees links an issue of trust and malfeasance with that of organizational culture by commenting:

> Trust is also an issue of style. Different people and different organizations have different styles and cultures. Sometimes, those cultures do not work together. It is something you will see in the due diligence processes. You will find out what type of people they are, whether they fit with how you do business and how you want to operate the business. Can you be a friend with those people?

It is, of course, true that different firms have different objectives in forming alliances and therefore expend different amounts of effort in reducing selection uncertainty. For instance, some entrepreneurial and small firms focus more on the procurement of financial resources and endorsement from large pharmaceutical firms with an exchange of their technological platforms (Stuart et al., 1998). In addition, different forms of collaboration pose different sets of concerns to firms searching for partners. A comment by a BD director demonstrates the former point about associations between alliance objectives and the life stages of firms:

> Different firms at different life stages in their lives worry about different things. If you are a very early-stage biotech company just being formed, what you really want is the first alliance with a big firm, because that provides funds to pay your bills and, more importantly, gives you credibility. What we are looking for now is partners that are committed to developing drugs and drug discovery. We've picked up a few therapeutic areas and decided to move our business to these certain therapeutic areas. And we are looking for partners who could facilitate building strong franchises. We are no longer looking for funding.

The following comment from a BD executive indicates connectionss between the form and content of alliances and selection uncertainty in reference to the partner's contribution:

> The importance of culture issues depends on what you are really proposing in the deal. If the success of the project or proposal depends on culture or people interactions, then we do not make a deal when the cultures are not going to get along. If the deal is something like "you have that, I am going to buy it, I now have that, and I do not need you anymore"—like licensing—your culture is not crucial.

These comments obtained from fieldwork show not only that reducing selection uncertainty is a major concern of firms in forming alliances, but also that each firm

faces different types and levels of selection uncertainty. The amount of effort necessary to reduce selection uncertainty is contingent on the type and content of exchange, as well as a firm's strategic objectives in forming alliances. These data highlight the importance of analyzing selection uncertainty and examining mechanisms that organizations use to reduce it.

Finally, it is important to note that although both partners bear the burden of selection uncertainty symmetrically in the case of mutual-collaboration alliances, the burden is asymmetrically distributed in the case of outsourcing-research alliances, in which it is essentially clients—large pharmaceutical firms—who bear more of the burden. Although this asymmetry issue is dealt with in statistical analyses by using a dummy variable indicating whether a partner is a large pharmaceutical firm, it is tentatively presumed here that partners symmetrically share the burden of selection uncertainty and attempt to ensure prospective partners' technical competence, reliability, and appreciation of the value of alliances prior to their formation.

In this chapter I provided a profile of the biotechnology (or biopharmaceutical) industry and a historical overview with a strong emphasis on issues of uncertainty and alliances. It is argued that the biotechnology industry has faced a higher degree of uncertainty in procuring financial resources and increasing the legitimacy of its existence. Two of the notable characteristics of this industry are interorganizational interdependence and collaboration. Most existing biotechnology firms do not have an entire platform for both upstream and downstream activities in drug-discovery processes. In addition, the large investment of financial resources for research and development (R&D), as well as the recent difficulty in procuring them, encourages firms to blur organizational boundaries to gain access to financial resources in large

pharmaceutical firms. Both technological and financial considerations transform the industry structures from: those in which firms independently conduct in-house R&D and commercialize the products to those in which firms are significantly interdependent through all phases of the drug-discovery process.

CHAPTER THREE: THREE UNCERTAINTY REDUCTION MECHANISMS

In this chapter I provide findings from fieldwork and reviews of previous research to answer the question of how organizations reduce selection uncertainty and what mechanisms enable them to do so. I identified three mechanisms for reducing selection uncertainty, which I termed (1) relational, (2) internal, and (3) contextual. This analysis led me to raise a new set of questions about (1) the interrelatedness among the uncertainty reduction mechanisms and (2) alliance performance. This chapter extends previous research on the embedded nature of economic behavior by unfolding alliance-formation processes in which organizations use various mechanisms to reduce selection uncertainty and select appropriate partners. In other words, one of the core arguments in this chapter is that it is not only social ties that help organizations reduce selection uncertainty.

On the basis of findings in the fieldwork, in which I conducted interviews with CEOs, presidents, and business development professionals at 2 nonprofit and 20 commercial biotechnology organizations, I found 3 ways in which organizations reduce selection uncertainty and termed them the three mechanisms for reducing selection uncertainty, or the three uncertainty reduction mechanisms. They are:

1. The relational mechanism: organizations cultivate pre-existing and ongoing social ties in reducing selection uncertainty.
2. The internal mechanism: internal capabilities and structures help organizations reduce selection uncertainty.
3. The contextual mechanism: prospective partners' credibility as it is revealed in context reduces the focal organization's selection uncertainty.

Before discussing details of each mechanism, I present a brief methodology of the fieldwork that I conducted in fall 1999. Fieldwork is an appropriate research method for this research because few studies have directly examined and provided detailed descriptions of alliance formation processes and the uncertainty reduction mechanisms (Eisenhardt, 1989; Strauss & Carbin, 1990). Confidentiality agreements with the interviewees limit disclosure in the organizational and individual profiles in Appendix 3-1.

All organizations are located in the Northeast United States. Of the 20 biotechnology firms, 12 (63%) were publicly held. Previous research reports that there are approximately 1,500 biotechnology firms in the United States and that about 350 (23%) are publicly held (Barley et al., 1992; Pharmaceutical Research and Manufacturers of America, 1999; Standard & Poor's, 1999). This over-sampling of the publicly-held firms indicates that certain cautions must be exercised in interpreting the following findings. One of the commercial firms had just entered the human therapeutic market from the agricultural biotechnology market. Primary profits at two of the commercial firms come from research on bionutrition science rather than human therapeutic biotechnology. Both of the nonprofit organizations are funded by state governments: (1) a state-level industrial association and (2) a research organization that not only conducts contracted research projects but also facilitates collaboration between firms, universities, research institutions, and hospitals in the state.

Recombinant Capital Biotechnology Alliance Database (ReCap) and Windhover's Healthcare Strategists were sources of information that I used in collecting vital data and identifying 65 publicly-held biotechnology firms in the Northeast. I sent letters to CEOs or BD executives in which I identified myself,

explained my research interests and project, and asked their collaboration for interviews (see Appendix 2-2). I followed up the letters after a week with phone calls to make appointments. I used the same contact procedure to set up meetings with privately-held firms, though I contacted only about 40 firms in the central New York area identified in the *Corporate Directory of Technology Companies.* The participation rate for the fieldwork was approximately 19% (20 out of 105 firms).

All interviews were conducted on their sites with one exception. The average interview time was approximately 80 minutes. Sixteen of the 22 interviewees have doctoral degrees in biology, chemistry, biochemistry, or medicine. I taped and dictated the 13 interviews with the interviewees' permission.

3-1: Alliance Formation Processes

In this section I provide only a brief description of alliance formation processes to avoid redundancy with the following discussions. Organizations conduct both passive and proactive searches. In a passive search, ego (the focal firm) is approached by alters (other firms or venture capitalists representing other firms). The interviewees at the 13 firms receive more than one piece of correspondence or phone call every day from alters who seek alliance partners. A BD executive commented:

> Because we are successful, a lot of people would like to work with us. Either a company itself, individuals who know people here, or investment bankers will present opportunities to us. So people are coming to us, sending a letter to us, calling us up, or sending a business plan to say: "Here is a particular opportunity. Are you interested in it?"

Two factors support a passive search. First, young and entrepreneurial firms that have not established their presence in the industry frequently approach prominent firms and

attempt to initiate collaboration to obtain endorsements and credibility for their growth and survival (Stuart et al., 1999).

Second, ego publicizes its interests in collaboration and solicits approaches from alters. One of the firms I visited, for instance, printed a 5-page BD brochure that was mailed to other firms and distributed at scientific, investment, and BD conferences. The brochure states: "We actively seek opportunities to join forces with other innovative companies so that together we can create breakthrough solutions to demanding medical challenges." The brochure also informs of (1) the firm's climate for partnering, (2) its history of productive partnering, (3) corporate development expertise, (4) possible areas of collaboration, and so forth. An alternative way to signal interest, particularly effective for small firms, is to participate in "resource showcases" at conferences where participants are able to make brief presentations about their technology, products, resources, strategies, and potential for alliance. Organizations are able to signal and publicize their interest in collaboration to attract other firms' interest.

On the other hand, the proactive search is one in which ego identifies and approaches alters because of a policy that "the company systematically uses alliances and collaboration in order to achieve strategic goals" (a BD director). In the proactive search, there are five phases: (1) defining alliance opportunities, (2) identifying prospective alliance partners, (3) making contacts, (4) completing due-diligence processes, and (5) making deals (see also Figure 3-1).

Organizations define alliance opportunities and determine prerequisites for prospective partners on the basis of business strategies, current technical strengths and

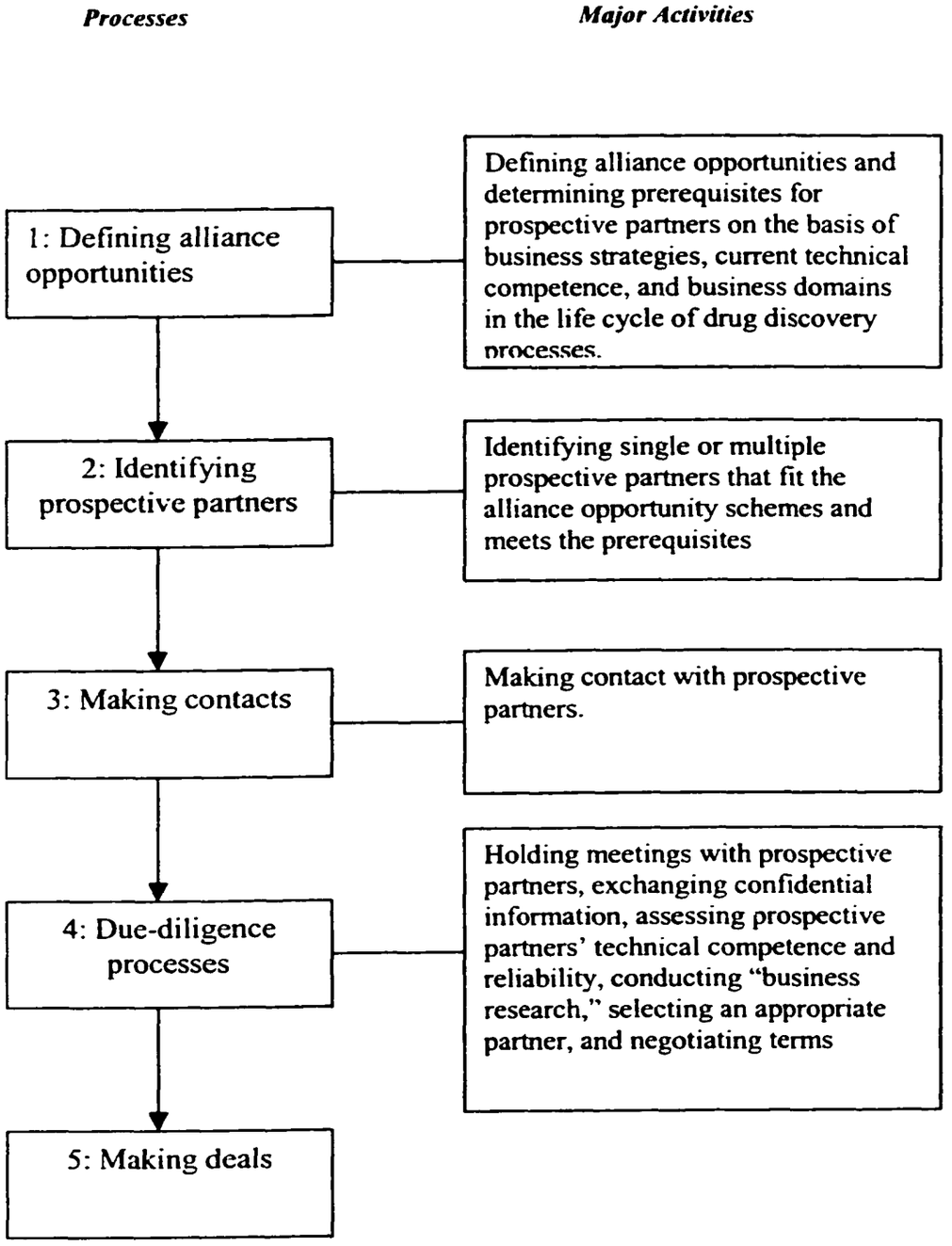


Figure 3-1: Alliance Formation Processes

weaknesses, and business domains in the life cycle of drug-discovery processes. This phase contributes to reduction of the commercial uncertainty, because it is the phase in which organizations decide how they are going to use alliances and other firms' resources to achieve their own strategic goals. For example, when a firm specializing in cancer and oncogene attempts to expand its business domain and enter diabetes-product areas with its technological strength in small-molecule drug discovery, the prerequisite for prospective partners is obviously expertise and knowledge in diabetes research.

After contacts are made, due-diligence processes are initiated in which organizations (1) hold meetings with prospective partners, (2) exchange confidential information, (3) assess prospective partners' technical competence and reliability, (4) conduct "business research," (5) select an appropriate partner who best serves their interests, and (6) negotiate terms. A joke made by a CEO who had just finished a 10-month due-diligence process with a large pharmaceutical firm, describes the essence of due-diligence processes:

> They did "bullshit detection" jobs or "bullshit filter" jobs. The only company that they (people from the pharmaceutical firm) left without having a loaded bullshit filter was our company. The bullshit filter is something (that) filters out bullshit. So when you leave somebody and you say, "The bullshit filter is loaded," that means that person was throwing bologna to you. When they left here, they compared notes in the parking lot and checked to see if all the bullshit filters were unloaded.

In the first part of the due-diligence processes, scientists assess prospective partners' technical competence by relying exclusively on their intuition and something "hard to be articulated." In meetings, scientists usually focus on (1) general questions

and (2) specific questions relevant to proposed projects. Asking general questions on biotechnology research and theory enables them to assess whether prospective partners know the fields, understand the processes of drug discovery, and have the know-how to apply scientific knowledge to actual drug development and commercialization. Asking specific questions, on the other hand, enables them to assess prospective partners' technical competence to conduct proposed projects.

A research-outsourcing alliance between a biotechnology firm and a large pharmaceutical firm offers a good example of how scientists make assessments in due-diligence processes. A pharmaceutical firm proposed an alliance to a biotechnology firm that had succeeded in creating several complex compounds out of natural resources in a very efficient way. After signing the nondisclosure agreement, scientists from the pharmaceutical firm began the assessment by asking such questions as What compounds did you make? How did you make them? How much did it cost? Can you make a compound like A? How will you make a compound like A? and How much will it cost? At that point the pharmaceutical firm did not disclose the compounds it wanted and, moreover, was not actually interested in compounds like A. It is evident that the scientists asked these questions to assess the biotechnology firm's technical competence on the basis of past performance and capabilities that might be relevant to the proposed project. The scientists then disclosed the compounds in which they were interested and asked such questions as Can you make it? How will you do it? and How much will it cost?

In the second part of due-diligence processes, such business professionals are involved as (1) attorneys, (2) finance professionals, (3) marketing professionals, (4) quality and manufacturing professionals, (5) doctors and medical experts, (6) clinical-

trial experts, (7) reimbursement or insurance experts, (8) top management, (9) BD professionals, and (10) some other organizations external to the proposed relationship. In general, while scientists and researchers tend to play more-crucial roles than other actors in due-diligence processes for the upstream projects in drug-discovery processes (i.e., early discovery), business professionals are more prominent in the processes for the downstream projects (i.e., clinical trials). That is because the assessment of prospective partners for the downstream projects requires knowledge and know-how for commercialization from the standpoint of a business professional.

Attorneys examine intellectual property issues. Reimbursement and insurance experts (or BD professionals) assess expected profits from proposed projects. Marketing experts (or BD professionals) estimate the size of potential markets and the profitability of proposed products. Finance professionals (or BD professionals) run financial models to assess risks and compute expected costs and returns on proposed alliances. In addition to these internal experts, organizations sometimes employ outside medical experts and consultants to ensure the commercial success of proposed alliances as well as prospective partners' technical competence. When proposed alliances involve manufacturing, organizations visit the other sides' suppliers to examine the suppliers' capability.

At the end of due diligence-processes, organizations negotiate (1) the terms of governance forms, (2) the amount of equity exchanged if any is involved, (3) the method of payment if any is involved, (4) the length of contracts, and (5) future contingencies.

Together with these five phases of the alliance formation process, the three mechanisms help organizations reduce selection uncertainty. Although the intensity of

the work and the amount of resources invested in each phase vary with the organizations and the alliances, all of the cases I examined in the fieldwork essentially progressed through these phases.

3-2: The Relational Mechanism

Both previous research and findings from the fieldwork reveal that organizations employ the relational mechanism, meaning that they use cultivated pre-existing and ongoing social ties in reducing selection uncertainty. It is generally known that social ties developed through a history of interactions provide information for decision making and shape organizational behavior (Kraatz, 1998; Shah, 1998; March & Simon, 1958; Myer, 1994; Nahapiet & Ghoshal, 1998; Pfeffer, 1981; Salancik & Pfeffer, 1978).

Work taking the embeddedness approach (Granovetter, 1985) is central to such an endeavor, providing evidence that organizations build interorganizational networks upon pre-existing and ongoing social ties in order to resolve selection uncertainty. Social ties are useful in reducing the technical-competence uncertainty because actors connected with each other are better able to transmit detailed, comprehensive, timely, accurate, and reliable information about prospective partners (Aldrich & Herker, 1977; Edstrom & Galbraith, 1977; March & Simon, 1958). Social ties also contribute to reduction of the contribution uncertainty because actors are able to transfer behavioral expectations developed from previous interactions to ongoing transactions (Larson, 1992; Uzzi, 1996). Expected future interaction also restricts opportunistic behavior in ongoing transactions (Heide, 1992; Parkhe, 1993). Both "shadows of the past" and "shadows of the future" originating from embedded ties create behavioral norms and reduce the risk of moral hazard and opportunism. The positive effects of social ties in

reducing selection uncertainty result in path dependency and the embedded nature of economic organizations, meaning that ongoing transactions tend to emerge out of pre-existing transactions or connections and that "in ongoing relations, human beings do not start fresh each day, but carry the baggage of previous interactions into each new one" (Granovetter, 1990: 99).

Eisenhardt and Schoonhover (1996) found that top management composition in high-tech firms influences the likelihood of alliance formation. Organizations are more likely to form alliances when their top management teams are larger, they have greater number of previous industry employers, and they have more senior executive experience in their careers. That is, "because top management team members are often the conceptualizers of alliancing strategy and the key sources of leads to potential alliancing partners, the social position of top managers is particularly relevant to opportunities for alliance formation" (Eisenhardt & Schoonhover, 1996: 140). Their findings provide empirical evidence that organizations use social ties for forming alliances.

Gulati and Westphal (1999) examined effects of CEO-board relations and content of interlocks on formation of joint ventures. Two of their major findings are that (1) a firm is less likely to form a joint venture with the board members' firm when the board of directors strictly monitors and controls management behavior, and (2) the firm is more likely to form a joint venture when the management-board relationship is more friendly. The friendly and cooperative types of interlocking and management-board relations create inter-management trust and facilitate inter-organizational collaboration by "enhancing confidence in each other's reliability and managerial

capability and lowering the perceived risk of opportunism" (Gulati & Westphal, 1999: 480).

Larson (1992) and Uzzi (1997) also demonstrated the importance of social networks as a foundation of inter-organizational relations. Larson (1992: 84), who found that when two entrepreneurs' shared the experience of working in the same firm, the likelihood of collaboration between their firms increased. She concluded that "concrete personal relations provided a conducive frame for economic exchange." Uzzi (1996) likewise found that collaborative inter-organizational ties in the New York fashion industry emerge from previous personal relations and third-party referral networks. Both Larson (1992) and Uzzi (1996) argued that organizations use such personal social networks as a foundation of inter-organizational ties, because organizations can transfer behavioral expectations from pre-existing relations so that they can manage opportunism and metering problems. Norms of reciprocity and trust developed in other social contexts discourage alliance partners from behaving opportunistically in the alliance contexts. History of personal relations provides a new context and opportunity for organizations to form alliances by reducing the risks of malfeasance and opportunism. Social ties are also enriched sources of detailed information about prospective partners rarely exchanged between actors socially unconnected. Information about prospective partners' competence is not always explicitly available so that social ties play a crucial role as information channels for searching and selecting alliance partners.

Organizations not only use previous personal ties but also previous organizational ties (Gulati & Gargiulo, 1999; Podolny, 1994). Previous organizational ties enable organizations to learn what kind of resources the partners have and how the

partners will collaborate in alliances. This knowledge obtained from previous relations reduces search costs for new alliance partners and increases a probability of repeated ties. Gulati and Gargiulo (1999), in their study of 166 firms' alliance activities between 1980 and 1989, found that two organizations having prior collaboration history are more likely to form alliances with each other. The finding in a study by Podolny (1994), who analyzed investment banks' syndicate formations, supports the significance of the role of repeated ties in reducing selection uncertainty. Podolny's particular contribution resides in a finding that organizations use repeated ties in forming alliances especially under highly uncertain conditions. When an investment bank forms a syndicate to issue and distribute highly uncertain "junk" bonds, it selects as the syndicate members other investment banks with which it has prior transaction experience. Prior exchange relations are an important source of information about who has the greatest knowledge and who is the best partner for collaboration.

Results from my fieldwork also suggest the usefulness of the relational mechanisms in not only reducing selection uncertainty but also facilitating alliance formation processes. For instance, the interviewees emphasized the importance of pre-existing relationships in making contacts to initiate discussion of possibilities of alliance. Because it is likely that prospective partners and, particularly, large pharmaceutical firms constantly receive correspondence and phone calls from a number of other firms interested in collaboration, organizations searching for prospective partners need to compete for attention and priority. Social ties are helpful in gaining attention and priority, not only because norms of reciprocity developed from previous interactions motivate prospective partners to give feedback but also

because familiarity saves time and resources in shaping general ideas on prospective partners. Indeed, one of the firms I visited implements an informal policy taking advantage of social ties, as the following comment from a BD director shows:

> Once we come up with the list (of prospective partners), then we use the best personal contact we have here to call the best personal contact at the other company. Scientists or business people. So if our CEO knows someone in a certain pharmaceutical company, like a head of research and development, I am going to ask him 'Can you make an initial call?' If I know the head of business development well, I would make a phone call to the head of business development. If our chief scientific officer knows their chief scientific officer best, we place the call. We usually try to leverage personal relationships and people who know the other persons on the other side. And, ideally, we want to make a call at the more-senior level because that is you will get a fairly clear understanding (about) whether there is a strong interest or there is not. Why do we do that? When there is an existing rapport and existing relationships, it is an opportunity to leverage the existing relationships.

Another BD director points out that pre-existing social ties (i.e., collegial relationships between scientists) create an open atmosphere in meetings and encourage information exchange in due-diligence processes. Pre-existing knowledge of prospective partners also reduces the necessity for collecting further information on them and speeds up due-diligence processes. Moreover, pre-existing ties, particularly between top executives, are useful in resolving problems and "getting things getting stacked, un-stacked" in negotiation processes. A BD executive commented:

> When the negotiation gets difficult, when you deal at the business level, when they are trying to push too hard, we know we can then circle back through the top and get the message across to the people pushing too hard, being unreasonable, and not being responsive enough to move fast.

The usefulness and benefits of pre-existing and ongoing social ties are most evident in identifying prospective partners in alliance formation processes. Organizations have three approaches that can be characterized by a concept of the strength of ties between actors from which alliances originally emerge and from which organizations primarily procure information on prospective partners: (1) strong ties, (2) weak ties, and (3) no ties. The strength of a tie is defined by Granovetter (1973: 1361) as "a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie" (see also Marsden, 1990).

Before turning to a closer examination of these approaches, a few remarks should be made regarding the number of prospective partners identified. Although the number depends upon the nature of the proposed projects or products in alliances, it does not usually exceed five. Because biotechnology is not a commodity industry where a number of firms possess identical technology and produce identical products, the number of prospective partners with the expertise required for proposed alliances cannot be infinite. There are, for instance, only 3 or 4 firms in the United States that have expertise in extracting and creating complex carbohydrates out of natural resources. In addition, the number of prospective partners identified also depends upon the identification approaches: while only a single prospective partner tends to be identified when searching organizations use strong ties, multiple partners tend to be identified when they use weak or no ties.

In the first approach, the information source is pre-existing or on-going strong ties. Familiarity developed from a history of frequent interactions enables actors to locate searching technology and resources and thereby contribute to reduction of the

technical uncertainty. In addition, actors are able to transfer pre-existing behavioral expectations to future transactions and thereby reduce the contribution uncertainty (Heide, 1992; Parkhe, 1993). Another advantage of strong ties in identifying prospective partners is low search cost. Because actors constantly receive information on prospective partners from various social occasions, they do not have to make a specific investment in information procurement.

Strong ties useful for identification exist at both organizational and personal levels (Eisenhardt & Schoonhoven, 1996; Gulati & Gargiulo, 1999; Gulati & Westphal, 1999; Larson, 1992). At the organizational level, there exist repeated ties and the board of director ties; the personal-level strong ties emerge from shared social and professional activities. Some examples of the strong ties I found in the fieldwork are as follows:

1. The foundation of a recent alliance between firm A and firm B is traced back to a small collaborative research project more than 10 years ago. These two firms used to be located in the same geographical area. They have maintained relationships and formed a number of alliances and research consortiums for various purposes since then.
2. The origin of an alliance between firm C and D is the direct interlocking relationship. A CEO at firm C has sat on the boards of both firm C and D since he helped founding firm D about 5 years ago. The CEO knows the technological strength and weakness of the two firms, and this familiarity resulted in the alliance formation.
3. A senior scientist at firm E has known a member of the board of directors at firm F since they used to work for a bio-agricultural government project under the Kennedy administration. When firm F approached some firms to start collaboration for entering into human therapeutic applications, this connection helped firm E build a bridge between firm E and F.
4. Senior scientists at firm G and H have known each other for more than 20 years, when they used to work for a large pharmaceutical firm. This collegial relationship helped the two firms form an R&D alliance.

Alliances, however, do not always emerge out of strong ties. The second identification approach is for organizations to use weak ties in procuring information and identifying prospective partners. This second approach is similar the first in that both contribute to reduction of selection uncertainty through a history of interaction with little searching cost. However, weak ties' contribution to the reduction is weaker because the limited interactions and shared personal history decrease the amount and quality of information exchanged as well as the levels of pre-existing trust. That is probably why I found that organizations taking the second approach tend to identify multiple, rather than single, prospective partners. The interviewees pointed out three occasions from which weak ties primarily emerge: (1) conferences, (2) business trips, and (3) third-party referrals.

A number of biotechnology conferences are regularly held for scientific, investment, and BD purposes to which biotechnology firms send their scientists and BD professionals to initiate new interactions and connections (Nohria, 1992). A BD executive commented:

> Our scientists have contact with others at research meetings and research presentations. That (contact) has value at both the purely scientific level and the social level. People know one another, exchange information, and talk informally. We are finding out what other people are working on, what opportunity is out there, and what companies might be interested in work we are doing.

Another BD director also commented:

> After they (scientists) go to a conference, they will tell me what is going on in the industry as well as with other companies and usually tell me whom they met at the conferences. It happens frequently.

Business trips also provide such opportunities to initiate interactions. It is not unusual in the biotechnology industry for scientists and BD professionals to visit other biotechnology and pharmaceutical firms' laboratories in the U.S., Europe, and Japan to make presentations and exchange ideas and information on ongoing research projects. Business trips are opportunities to not only signal and publicize organizations' technical competence but also obtain information on other firms' activities and general technological advancement. Organizations are able to use the information acquired through business trips in considering appropriate alliance partners. For instance, the origin of an alliance between a U.S. biotechnology firm and a Japanese pharmaceutical firm for diabetes-related products is traced back to business trips made by U.S. scientists and BD professionals about 4 years ago. The U.S. firm hired a licensing consultant in Tokyo who had connections with a number of Japanese pharmaceutical firms and visited approximately 20 firms through his connections. Presentations on upcoming research projects made by the U.S. scientists attracted an attention from a senior researcher in one of the Japanese firms, which resulted in a discussion of possibilities of forming alliances.

While weak ties originating from conferences and business trips are based upon contagion, they also emerge from third-party referrals and structural equivalence, meaning that two actors who are unconnected directly are connected to the same third parties (Burt, 1987; Scott, 1991). Examples of third parties include (1) other organizations with which searching organizations have previously had business

transactions, (2) venture capitalists, (3) professors or scientists in universities or research institutions, and (4) industrial associations.

Organizations use third-party referrals in identifying prospective partners for the following two reasons. First of all, the searching cost is small, though searching organizations somehow may need to return favor to third parties in the future. Second, because they are familiar with the technical competence, research programs, needs, and problems of both searching organizations and prospective partners, third parties filter inappropriate matches out of potential combinations so that searching organizations can use third parties' matching capabilities in reducing selection uncertainty. A director at the industry association pointed out this advantage of third-party referrals:

> For instance, someone (in a biotechnology firm) calls me up and says 'Rachel suggested that I talk to you.' Rachel and I went to the same graduate school. And we've known each other for a million years. It is much easier if I know this somebody who has already been in my network. This is easier because I value Rachel's judgement. So, if she tells me 'I met with Dr. so and so. Would you help him out with some of his projects? He is very smart. He has very interesting technology.' I know Rachel is smart. I know she knows how to assess technology. So I believe what she has said.

Here, Rachel filters out hundreds of the possible combinations in her network and finds the best one in her discretion. Both of the actors being connected by Rachel trust Rachel's judgement, so they are able to save spending resources on identifying and understanding prospective partners.

Although this usefulness of strong and weak ties in identifying prospective partners has been previously reported in many different places (i.e., Aldrich & Herker,

1977; Edstrom & Galbraith, 1977; Larson, 1992; March & Simon, 1958; Uzzi, 1996), previous studies have paid little attention to the third identification approach: BD professionals initiating the identification process by systematic environmental scanning and proactive information procurement on prospective partners from public records. Because the identification is not based upon pre-existing or ongoing social ties, BD professionals, who obtain contact information from industry directories and the Internet, frequently make cold calls to express their interest in collaboration and initiate the alliance formation process. This third approach is different from the others in the following two ways. First, organizations need to bear the burden of searching costs, which encompass, at least, the staffing costs of BD professionals, subscription costs to various information sources, and costs for contacts and communication.

Second, organizations taking this approach place less value on social ties than do those taking the other approaches. Information relevant to reduction of selection uncertainty does not come primarily from social ties. Rather, by exploring such databases and information archives as industry newsletters, trade journals, press releases, firms' Web sites, SEC filings, and commercial databases (e.g. Bioscan, ReCap, Strategic Intelligence Systems), BD professionals conduct systematic environment scanning and procure information on other firms' (1) products, technology, and resources; (2) ongoing projects; (3) ongoing clinical trials; (4) previous alliance experience; (5) intellectual property and patents; and (6) financial situations. A BD director commented:

> I have basic background information about companies from databases. We get literature circulated everyday like the BioWorld. I constantly read what is going on in this industry and what other companies are doing. So I have a

> pretty good sense of what a large percent of the biotechnology companies are doing.

For another instance, one of the firms in the fieldwork structures BD and strategic information units that are responsible for publishing internal daily bulletins on biotechnology and pharmaceutical industries. The newsletters contain such information as (1) new FDA-approved products, (2) the progress of clinical trials, (3) mergers and acquisitions, (4) alliances, (5) financial deals, (6) patent issues, and (7) general business strategies. In the publication process, the BD professionals archive information on almost all firms in the industry and construct internal databases. They use the databases in searching for certain technologies in other firms and identifying prospective alliance partners.

Results from the fieldwork support previous research findings that organizations use pre-existing and ongoing ties in collecting information on prospective partners so that interorganizational networks become embedded in pre-existing and on-going ties. In addition, such ties facilitate various aspects of alliance formation processes (i.e., making contacts, due-diligence processes, and negotiations). I also found that there is variety in alliance origins: (1) strong, (2) weak, and (3) no ties. While it is certain that some alliances emerge from embedded and strong pre-existing ties, others do not. There is a difference in where interorganizational networks come from and how much value organizations place on pre-existing and ongoing ties in procuring information on prospective partners and forming alliances.

Findings about relationships between the ties and opportunism or trust are mixed. As opposed to a number of previous studies that place great emphasis on the effect of ties on building trust and discouraging malfeasance (i.e., Baradach & Eccles,

1989; Das & Teng, 1998; Dyer & Singh, 1998; Granovetter, 1985; Larson, 1993; Perrow, 1992; Powell, 1990; Uzzi, 1996; Zucker, 1986; Zucker et al., 1996), surprisingly, only a few interviewees agreed with them. There might be 4 possible reasons for this weak support of the idea of the usefulness and benefit of social ties in reducing the contribution uncertainty (Granovetter, 1985).

First, when proposed alliances are aimed at collaboration downstream in drug-development processes which require fewer interactions between scientists than do those at upstream, organizations do not consider "cultural mismatch" or "cultural difference" to be a crucial factor. Second, because the biotechnology industry is relatively small, reputations travel very quickly throughout the industry. The threat of a bad reputation controls cheating and opportunistic behavior so that it is less necessary for organizations to consider issues of trust and reliability in forming alliances. Third, biotechnology is an industry of science, where a majority of the scientists, CEOs, and BD professionals hold doctoral degrees. Actors in the industry are presumed to be fundamentally competent, qualified, and faithful. Finally, biotechnology firms are typically founded upon unique technology. Regardless of the concerns of reliability and trust, it is sometimes necessary for organizations to form alliances in order to gain access to prospective partners' unique technology needed for conducting proposed projects.

On the other hand, a few interviewees pointed out the importance of "personality of the entity," "management orientations," "culture," or "style." A BD executive commented:

> Different people and different organizations have different styles and cultures. Sometimes those cultures do not work together. It is something you will see in

> the due-diligence process. You will find out what types of people they are, whether they fit with how you do business and how you want to operate the business. Can you be a friend with those people? ... During due-diligence processes, they (scientists and business professionals) learn soft aspects of what other parties bring to the table. You might look at a team on the other side and say 'I do not want to work with them. I do not trust them.' Or 'whatever the data say, I do not want to work with them.' It happens. It does happen.

Scientific and business meetings in due diligence-processes and social occasions along with these processes (e.g., lunches and dinners) provide actors insight into this "mental," "cultural," or "soft" aspects of prospective partners. A BD director commented:

> We usually have lunches every time we have meetings because we work for a long time. We sometimes have dinner. It is good to have dinner to get to know someone outside the very formal structures. We do not do enough of them. But it is important. If we have ten meetings, we have dinners with 25% of the meetings. In dinners, sometimes we exchange information about our organizations, say, where our company is going or what our ultimate goal is. You can do this within formal structures. But, sometimes, you can gain a lot of insights and what is more important than others in the partners over dinner. But, we talk about everything, depending on who you are talking to. Dinners connect you better.

Because the fieldwork was conducted only in the biotechnology industry, it is impossible to determine how much intrinsic characteristics and infrastructures in the biotechnology industry influence my observations. For instance, Zucker et al. (1996) found that trust and opportunism are important issues in building collaboration networks in the biotechnology industry and that biotechnology organizations tend to conduct research projects internally when they are predicted to deliver high scientific

and commercial values. I am not able to give conclusive answers on this point and must end up instead with the traditional plea for more research.

3-3: The Internal Mechanisms

The internal mechanisms mean that internal capabilities and organizational structures help organizations reduce selection uncertainty. The internal mechanisms consist of three sub-mechanisms: (1) collaborative know-how, (2) boundary spanning, and (3) technical intensity.

The first internal mechanism is collaborative know-how (Barkema et al., 1997; Doz & Hammel, 1998; Halebian & Finkelstein, 1999; Hill & Hellriegel, 1994; Lorenzoni & Lipparini, 1999; Powell, 1998; Powell et al., 1996; Simonin, 1997). Simonin (1997: 1154) defined it as "organizational know-how that determines how effectively new collaborations are entered and managed." A principle finding in this research perspective is that there is a learning component in alliance activities and that organizations learn better how to manage alliances and how to select appropriate partners as they accumulate alliance experiences.

Powell et al. (1996), in their study of 225 biotechnology firms, found that experience in managing various types of interorganizational linkages at time *t-1* (i.e., R&D alliances, financial ties, manufacturing ties, etc.) increases the probability of alliance formations at time *t*. The initial entrance into inter-rganizational networks develops skill at managing collaborations that facilitates further collaborative activities and engagement in networks. They concluded that:

> Firms can enter via R&D ties or by some other type of tie. Initial collaborative relationships trigger the development of experience at managing ties. R&D

> ties, directly and through increased experience, enable firms to access more diverse sources of collaboration (Powell et al., 1996: 138).

Barkema et al. (1997) examined how organizational experience in alliances affects performance of international joint ventures measured as their longevity (see Gulati, 1998, for performance measures of alliances). Using data on 244 firms from 1966 to 1994, they found that prior experience with domestic joint ventures and with international wholly owned subsidiaries increased alliance performance and concluded that there is a learning-by-doing process in which organizations gain know-how for increasing the performance of current and future alliances.

Simonin (1997) examined both antecedents and consequences of collaborative know-how with his survey data from 151 firms. As hypothesized, he found that alliance experience increases collaborative know-how and that organizations with more collaborative know-how are more likely to achieve perceived higher performance in alliance activities. He concluded:

> The results indicate that firms do learn from past collaborations by developing skills in identifying potential collaborators, negotiating the form and specifics of collaborative agreements, managing and monitoring the arrangements, knowing when to terminate them, and transferring knowledge. This collaborative know-how in turn allows firms to achieve greater benefits from collaborations (Simonin, 1997: 1167).

Haleblian and Finkelstein (1999) examined the effects of experience on the performance of mergers and acquisitions, another form of interorganizational activity. They found that performance, as measured by acquiring firm's stock price just after acquisition, increases when the acquiring firm has accumulated acquisition experience

similar to the current one. On the other hand, dissimilar experience does not help the performance, because know-how for mergers and acquisitions is case-sensitive, meaning that different types of acquisitions require different sets of learning, skills, and know-how.

These empirical studies suggest the importance of alliance experiences and a role for organizational learning in reducing selection uncertainty. Organizations learn, through accumulating experiences and developing collaborative know-how, how to manage alliances and how to select alliance partners.

Organizational learning is a process in which organizations, groups in organizations, and organizational members create and improve routines so as to achieve certain objectives (Levitt & March, 1988: 320). As they accumulate experience, organizations develop methods or criteria to assess prospective partners and examine whether or not prospective partners can best serve their interests.

In general, routines are explicit or implicit programs that specify behavioral patterns for responding to problems (Ashforth & Fried, 1988; Gersick & Hackman, 1990; March & Simon, 1958). Organizational members do not always conduct "search activities": collecting relevant information, evaluating responding alternatives, and making decisions (Simon, 1945). Much concrete behavior in organizations is habitual and is governed by bounded rational cognition. Organizations often proceed problems "mindlessly" and conserve their cognitive capability by using routines (March & Simon, 1958).

Standard operating procedures for inventory or budgeting (Cyert & March, 1963; March & Simon, 1958) are representative examples of routines at the organizational level. Individual skill is also a system of routines. Stinchcombe (1990:

33) noted that "skilled workers' skill consists of a set of routines, a set of smaller skills for particular tasks that they do very well, and many principles of decision which tell workers when to use one routine, when to use another."

A facilitator of organizational learning is the accumulation of experience (Cohen & Levinthal, 1990; Levitt & March, 1988). Learning-by-doing helps organizational members identify cause-effect relations on a trial-and-error basis in actual problem-solving processes. Successful and failed experiences teach the members what courses of action they should and should not take. Experience is also crucial because past experience provides frameworks and cognitive schemata on which the members map new experience (Cohen & Levinthal, 1990). Past experience helps individuals develop their own cognitive maps that increase individual capabilities to manage newly encountered problems and identify causal mechanisms for creating new routines (i.e., Pinch et al., 1997).

In this research context, routines that organizations develop through alliance experience are methods for assessing prospective partners. The BD professionals in the filedwork emphasize the importance of experience in doing BD work and pointed out that accumulating alliance experience contributes to learning (1) how they should scan the environment, (2) what information they should collect, (3) what information they should value, (4) how they should coordinate and facilitate due-diligence processes, and (4) how they should resolve problems in negotiation. Furthermore, the more-experienced BD professionals are better able to predict the market and environment in the future and assess whether or not proposed projects and alliances will be reasonable both commercially and scientifically. This learning effect is useful particularly for biotechnology firms because it takes more than a few years to

complete biotechnology R&D projects, meaning that BD professionals must determine the value of alliances for the future with their intuition.

In addition to individual "intuition" or "skills," learning also takes place at the organizational level involving routinization of alliance formation processes. One firm in the fieldwork has a checklist of due-diligence processes for alliances, mergers, acquisitions, and other forms of interorganizational relationships. During the first 10 years since its founding, the firm has experienced more than 30 interorganizational deals. The BD executive suggested in an executive meeting that they brainstorm on what aspect of prospective partners they should assess and value, what information they should collect, and who should take responsibility in assessing each aspect. The brainstorming resulted in creation of a checklist that consists of the following 13 analytical dimensions for due-diligence processes:

1. Financial (i.e., complete balance sheet data and detail of assets and liabilities)
2. Inventory (i.e., inventory value, finished product, work-in-progress, raw material by product line and location)
3. Permits and licenses (i.e., list of permits, environmental issues)
4. Plant, property, and equipment (i.e., lists of equipment for production and research)
5. Environmental (i.e., the status of prospective partner's site with respect to compliance with regulations)
6. Intellectual property (i.e., lists of patents, including terms of patents and validity)
7. Legal (i.e., lists and locations of all agreements and contracts that have a material effect on the business)
8. Research and development (i.e., review of the key technologies used in running the business)
9. Product strategy (i.e., new product development and anticipated sales)
10. Sales and marketing (i.e., review of sales personnel and their territories worldwide, 3-year sales by product category)
11. Manufacturing (i.e., manufacturing methods and processes)
12. Human resources (i.e., interviews with key personnel in each functional area)

13. Management (i.e., management view of the business and future direction)

Under each of these analytical dimensions, there are 4to 7 items. Because the firm uses this checklist for multiple purposes, its use is contingent on the nature of each proposed deal that involves unique characteristics and requires special attention. This checklist, as a result of experience and learning, is a routine that sets analytical dimensions in assessing prospective partners, coordinates interdependence between members in due-diligence teams, and facilitates alliance formation processes. Therefore, as found in previous research as well as my interview research, I claim that collaborative know-how is one of the internal mechanisms that organizations use in reducing selection uncertainty.

The second internal mechanism is boundary spanning. According to the open-system view of organizations, organizations consist of two systems: (1) core technology and (2) boundary spanning (Katz & Kahn, 1973; Thompson, 1967). While core technology is a system that transforms input into output, boundary spanning of organizations "seals off their core technologies from environmental influences" (Thompson, 1967: 19). Organizations use boundary spanning to "buffer environmental influences by surrounding technical cores with input and output components" (Thompson, 1967: 20). Assembly lines and purchasing departments in manufacturing firms are good examples of core technology and boundary spanning, respectively.

There are two major roles of boundary spanning in organizations (Aldrich, 1979). The first role is external representation. Boundary spanners are representatives of organizations who transmit information to, and negotiate with the environment.

The second role is information processing. Boundary spanners gather and filter all relevant information from the environment and pass the filtered information to decision makers to avoid information overload.

An important structural characteristic of boundary spanning is isomorphism between environmental differentiation and structural differentiation. Thompson (1967: 70) argues that "under norms of rationality, organizations facing heterogeneous task environments seek to identify homogeneous segments and establish structural units to deal with each." Organizations absorb environmental differentiation and complexity by structural differentiation because localized and specialized subunits are more able to process complex information (Hage & Aiken, 1967).

Organizational leaders (i.e. presidents or CEOs) are major actors who identify potential alliance partners and initiate discussions for alliance formation. This is particularly true when (1) organizations are too small to differentiate their structures and have unique subunits dedicated to activities for alliance formation, (2) organizations do not frequently form alliances, so it is not cost efficient to hire personnel dedicated to alliance formation activities, and (3) the organizational environment and activities of other organizations are relatively stable, so that organizations are able to scan the environment without maintaining subunits possessing specialized information-processing capabilities (Aldrich, 1979; Blau, 1970; Lawrence and Lorsch, 1976; Thompson, 1968).

Otherwise organizations structure subunits dedicated to alliance formation activities, which are usually called "business development" (BD), "corporate

development", or "technology development." The BD professionals[2] in the fieldwork described themselves differently. BD professionals are "network managers," for they form alliances and construct inter-organizational networks. BD professionals are also "gatekeepers" and "intrapreneurs," for they filter information from the environment, pass relevant information to decision makers (i.e., top management or scientists), and propose emerging alliance opportunities. BD professionals are also "people of body-contact sports", for a crucial part of their role is to make contacts and go to see people in prospective alliance partners. A BD director summarized the roles of BD professionals as follows:

> What I do here is to define alliance opportunities, identify sets of potential partners, do some research about these partners, select one or some of them, make contacts, initiate the discussion, arrange many scientific and business meetings, and make the deals.

BD professionals also do some financial analyses as well. Their analyses obviously contribute to reduction of the commercial uncertainty. A BD executive commented:

> Inherently it (an alliance) has to make financial sense. We are in business. I have an entire group (in the BD unit) devoted to risk assessment and financial modeling to be able to say about particular projects and evaluations. They judge the markets and understand clinical implication – for what the product will be useful, how high you can price it. They put together entire financial views of a particular program and decide how much the project is going to cost us to do what we are saying. The project has not only technical risks but also market risks. Getting a product approved by the FDA is the first of the

[2] Precisely, professionals are defined in sociological literature as "exclusive occupational groups applying somewhat abstract knowledge to particular cases" (Abbott, 1988: 8). Because there seems to be no occupational group that controls the knowledge and skills of incumbents in BD units, it may not be correct to term BD persons professionals. However, for the convenience of this research, I use this term loosely.

> processes for success. You have to understand how much revenue you can make and what kind of marketing investments you have to make.

Their descriptions of BD professionals show that they are boundary spanners who are "more tightly linked to the environment than others" (Aldrich, 1979: 248). They facilitate and coordinate alliance formation processes by representing organizations, procuring information from the environment, transmitting information to both the environment and internal scientists and top management, and negotiating with prospective partners. In addition, by running financial models and predicting the effects of alliances on markets and profitability, BD professionals reduce the commercial uncertainty. It is therefore reasonable to claim that structuring BD units and hiring BD professionals contribute to reduction of selection uncertainty.

The third internal mechanism is organizational technical intensity. It enables organizations to increase their capability to assess the technical competence of other organizations (Cohen & Levinthal, 1990). Technical intensity denotes the extent to which organizations are sophisticated in terms of their technology and is typically measured by the proportion of expenditures of R&D activities to revenues (i.e., R&D costs divided by sales) (Milkovich et al., 1991). Technical intensity - how intensively organizations invest financial resources in R&D activities relative to their profit - not only indicates firms' technical superiority but also their ability to understand and evaluate technological advances in the environment.

Cohen and Levinthal (1990) claim that because the value of new knowledge is determined by the extent to which it expands and changes current knowledge, the value of emerging technology and cutting-edge scientific findings cannot be assessed

without mapping them to systems of knowledge and broad cognitive schemata. One cannot judge the contribution without making it clear what we have known.

In scanning the environment and understanding research activities and product-development projects in other firms, the scientists, researchers, and business professionals in industries where technological knowledge is crucial for running business (i.e., the semiconductor, biotechnology, and software industries), need to understand the current state of technology and science to which new knowledge and technology are added. Cohen and Levinthal (1990) argue that more investment in R&D activities enables organizations to develop the knowledge map and the cognitive schemata, useful for assessing the value of technological and scientific advancement in the environment. When organizations have a higher degree of technical intensity, they are more able to assess cutting-edge technology and, thereby, reduce selection uncertainty about prospective partners' scientific and technological contributions and commercial value of gaining access to their technology through alliance formation.

The effects of technical intensity on reduction of selection uncertainty become most evident in due-diligence processes in which scientists and researchers assess prospective partners' technical competence and general understanding in biotechnology, chemistry, molecular science, and medicine and specific knowledge related to proposed collaborative projects. One BD executive commented:

> There are different ways of interpreting the same information and facts. It is understandable if your are in a small company and this is your program or project. You will look at it very positively. You will say 'This is going to cure cancer. Therefore, this is going to be a big product." From my standpoint, I will say that there are only 5 cancer products on the market that have over 500 million-dollar revenues. The possibility is very low that yours is going to be the sixth one.

This comment of his demonstrates that scientists and BD professionals must have insight in interpreting data and information presented by prospective partners in due-diligence processes and in judging whether or not obtained data are worthy, reliable, reasonable, and credible, for the same data can be interpreted in different ways depending on the positions that social actors occupy (Vaughn, 1994). In addition, they need to constantly update the state of their knowledge for judging whether or not what is claimed to be new and valuable by prospective partners is really new and valuable. Higher levels of technical intensity facilitate reduction of selection uncertainty about prospective partners' technical competence by helping organizations shape a general understanding of the state of knowledge and map cutting-edge technologies in the cognitive schemata.

3-4: The Contextual Mechanism

The contextual mechanism operates on the principle that prospective partners' credibility, arising from their reputations, signals technical competence and reliability, so that credibility decreases searching organizations' need to reduce selection uncertainty. In other words, searching organizations (or the focal organizations) should not be very concerned with selection uncertainty when prospective partners have achieved a high reputation in industry.

Previous research suggests 3 crucial roles of reputation in interorganizational exchange. First, organizational reputation enhances power over other organizations and the capability to procure resources and social support (Perrow, 1961; Rao, 1994; Thompson, 1967). Second, establishing exchange relations with highly reputable organizations lends partners recognition, acceptance, and legitimacy (Podolny, 1993).

Third, positive reputation signals past performance, expected future behavior, and positive attributes (Weigelt & Camerer, 1988). The last feature of reputation is relevant to this research context.

In a world of imperfect information, where cause-effect relations are unclear, social actors consider reputation to be a reliable source of information in screening exchange partners (Podolny, 1994; Stuart, 1998; Weigelt & Camerer, 1988). A prospective partner's high reputation signals the quality of technical competence and contribution in alliances. Reputation provides information relevant in selecting alliance partners and decreases the organizational need to resolve selection uncertainty.

Interviewees in the fieldwork constantly use information on the prospective partners' knowledge of patents and publications not only for intellectual property purposes, but also for assessment of their commercial and technological capabilities. They value the information, because biotechnology is a research-intensive and knowledge-driven industry in which patents and publications directly indicate the prospective partners' degree of technological sophistication, quality of research, and areas of research activities. It is also valuable because their firms are able to collect and obtain the patent and publication information without extensive cost.

Another component of reputation is prospective partners' alliance history. One of the interviewees commented that alliance history signals (1) the area of research in which the prospective partners are interested for collaborative programs, (2) the presence and performance of commercial products delivered through previous alliances, and (3) prominence of their prior alliance partners. The third role of signaling is indeed reported in Stuart et al. (1999), in which the authors state that

organizations forming alliances with other prominent organizations are faster to issue initial public offerings (IPO) and more able to procure capital at the point of IPO. The reason is that the specific alliance history provides endorsements and, in other words, certification of a high degree of prospective partners' technological sophistication.

Furthermore, two of the cases I met in the fieldwork illustrate organizational usage of reputation in forming alliances. A CEO in a bionutrition firm received a cold call from a manager in a large food-science company who proposed a collaborative research project. The manager had heard of the bionutrition firm from a friend who worked with her several years previously. On the other hand, the CEO did not know the manager personally but trusted her and her firm from the outset of the alliance formation processes. That was because he knew indirectly through an article in an industrial journal that she had won an award at a food-science conference. The article and award increased her credibility and reduced the CEO's uncertainty about her technical competence and reliability.

The second case is that of a small bio-agricultural firm that was looking for alliance partners who could help it move into human therapeutic fields with its basic technology. In that transition time, the firm initiated a research project on crop diseases with the USDA (United States Department of Agriculture) and had an opportunity to make a work-in-progress presentation about the project in one of the USDA workshops. To the small firm, the workshop was an opportunity not only to exchange information and ideas to advance the collaborative research project but also to publicize and advertise its connection with the government agency and the agency's endorsement of its technical competence (Stuart et al., 1999). Right after the

workshop, a scientist in a large chemical firm approached and initiated a discussion of collaboration.

3-5: Bounded Rationality and Selection Uncertainty

One thing that should be emphasized here is that, although I stress the importance of alliance formation processes and mechanisms for reducing selection uncertainty, I do not mean to assert that organizations are able to resolve it completely prior to the formation and that organizations do not have to make efforts to manage alliances and maintain relationships after alliance formation.

Because of bounded rationality (March & Simon, 1958; Simon, 1961), organizations are unable to predict all contingencies and resolve all relevant uncertainties completely beforehand. Bounded rationality refers to human behavior that is "intendedly rational, but only limitedly so" (Simon, 1961: xxiv) and describes the cognitive limits of individual decision makers. If there were not any bounded rationality constraint, actors could specify completely the appropriate sets of contingent actions prior to alliance formation (Williamson, 1975). Therefore, the incomplete resolution of uncertainty requires problem resolution and persistent commitment and investment in maintaining and managing interorganizational relationships after organizations form alliances. Because this issue is pertain to how organizations manage alliances, which is beyond the scope of this research, I am going to present just 3 cases illustrating bounded rationality in resolving selection uncertainty and its results.

The first example is an alliance for screening and drug discovery that was initiated by personal connections between the two senior scientists who used to work for the same pharmaceutical firm. At the time when the two firms formed the

alliances, about two years previously, Wall Street did not expect both of them to be profitable and deliver dividends right away. The two firms experienced the similar pressures for immediate profits and had the same time and management orientation (Lawrence & Lorsch, 1967). However, that situation changed when Wall Street expected one of the firms to deliver values and placed more pressure on it. The different amount of pressure created 2 different time and management orientations and different views of the alliance in the 2 firms. While one of them, under more pressure, attempted to move the project quickly and create visible values out of the alliance, the other responded slowly, had fewer priorities, and focused on fundamental research activities. These firms, though recognizing that problems were caused by the difference in expectations, now have difficulty in finding appropriate resolutions and maintaining the relationship.

The second example, which may be more intrinsic to the biotechnology industry, is an alliance for finding and selecting new chemical compounds out of thousands of possible compounds for cancer-related products. The origin of this alliance was that a BD professional in one of the firms learned of the other side's alliance with a third firm and made a cold call to propose a similar. While the allying firms maintained a good relationship and conducted the project collaboratively the alliance was not technically successful in that the compounds they found did not have any commercial value. The BD director in one of the allying firms commented: "Screening for drug development is a random process. ... Science is hard. We did not find anything worthwhile. That happens."

The last example is a 50-50 joint venture for HIV research between firms X and Y, which was initiated between top managers who first met at a quasi-scientific

conference. X had been developing its expertise in screening techniques for a long time. Y was held in high opinion by the industry for succeeding in collaboration with another pharmaceutical firm to develop very profitable drugs for HIV. X and Y were responsible in the joint venture for screening and biochemistry research, respectively.

According to a BD executive in X, 3 problems arose just after formation of the alliance. First, "enthusiasm, energy, and investment in the alliance" were asymmetric: while X screened some possible compounds for the targets and passed the outcome to Y, Y did nothing. Second, although X had obtained information prior to the alliance formation that Y had played a leading role in the alliance with the pharmaceutical firm in which they developed profitable products, it turned out the information was wrong. Y's role in the alliance was peripheral and limited to offering the pharmaceutical firm access to its chemical-compound library. X's scientists became dubious about Y's technical capabilities for drug development. Third, about a year after the alliance formation, all the top managers at Y, who initiated the collaboration, were replaced with a new management team that did not value the collaboration. It terminated the collaboration in the belief that Y was able to conduct the project with its internal capabilities.

There exists unique uncertainty in each of the three examples that the organizations, because of bounded rationality, failed to resolve prior to alliance formation. In the first example, the uncertainty was future pressure for profitability from Wall Street. In the second example, it was the randomness of the screening processes in drug discovery. In the third example, it was the top management change at Y, as well as failure in reduction of the technical and contribution uncertainty. Although organizations are able to reduce selection uncertainty, some other

uncertainties remain even after lengthy due-diligence processes, so that contingencies that allying organizations encounter afterwards require constant efforts from both parties to redefine, maintain, and improve the relationships. Even though it is important to reduce selection uncertainty prior to alliance formation, that activity does not automatically determine alliance performance.

3-6: Discussions and Limitations

To answer the question of how organizations reduce selection uncertainty, both previous literatures and the fieldwork suggest the 3 mechanisms: (1) the relational mechanism, (2) the internal mechanisms, and (3) the contextual mechanism (see also Figure 3-2). Organizations use social ties in procuring information on prospective partners and identify prospective partners from various levels of tie strength. Although interviewees in the fieldwork did not emphasize strongly, previous literature also stress that organizations build interorganizational networks upon social ties, because actors are able to transfer behavioral expectations developed from previous interactions to current transactions and reduce the contribution uncertainty. The internal mechanisms consist of the three submechanisms: (1) collaborative know-how, (2) boundary spanning, and (3) technical intensity. Organizations are able to increase their assessment capabilities and thereby reduce selection uncertainty with accumulating alliance experience, gaining collaborative know-how, structuring units dedicated to alliance formation, and increasing their own technical competence. Finally, organizations are able to use prospective partners' credibility in reducing selection uncertainty because reputations signal the technical competence and reliability of prospective partners.

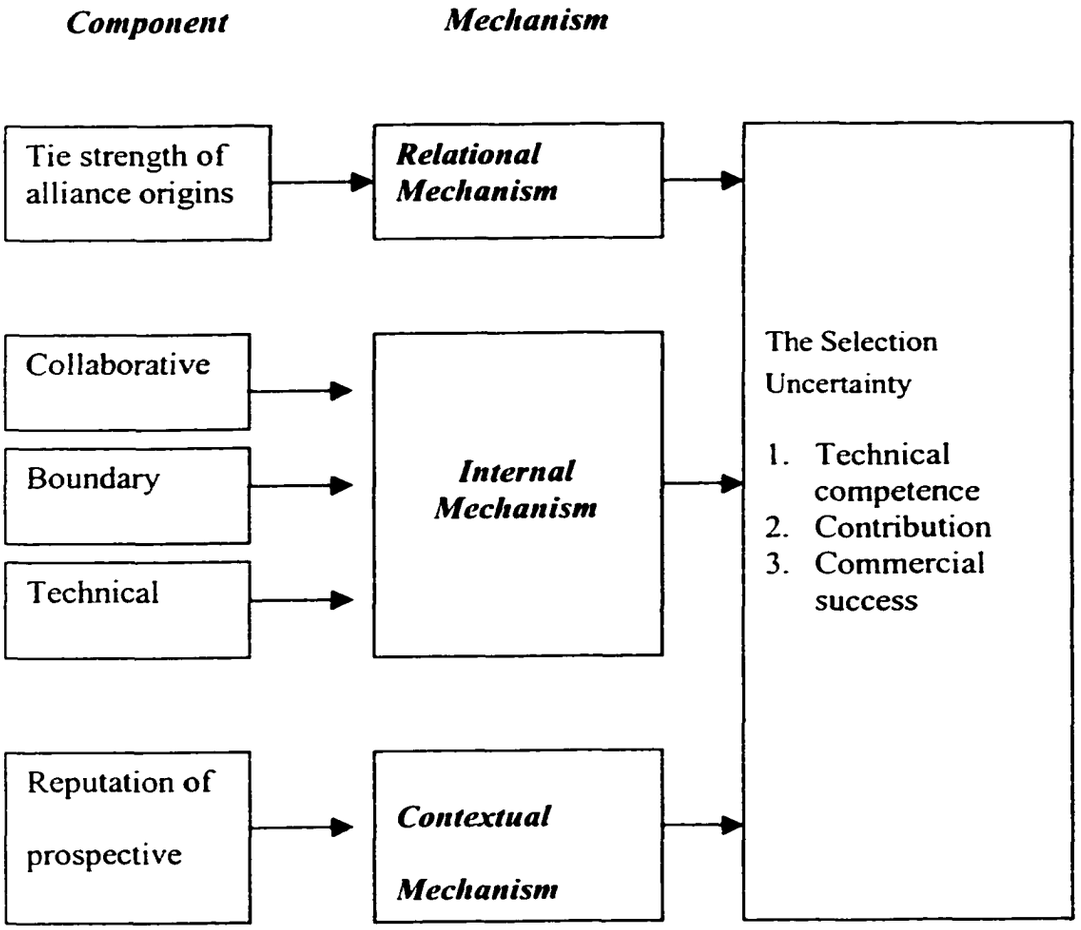


Figure 3-2: The Three Uncertainty Reduction Mechanisms

I believe that this research has so far made several contributions. The first contribution is that although previous literature stresses the importance of selecting appropriate partners to achieve complementarity and create "win-win" situations (Doz & Hamel, 1998), the selection processes and mechanisms that enable organizations to do so have not been clear. One of the contributions of this study is the identification and clarification of the uncertainty reduction mechanisms on the basis of previous literature and results from the fieldwork.

Second, though little effort has been made to unfold the alliance formation processes and examine interorganizational activities prior to alliance formation, this research proposed the five phases in the process and presented descriptions of organizational efforts in each phase to identify and select appropriate partners. It is certain that organizations need to resolve problems after alliance formation and work hard to improve the relationships. However, it is also true that an effort to forge high performing alliances starts even prior to their formation. This suggests that researchers interested in alliance performance should consider alliance formation processes and mechanisms for reducing selection uncertainty to be one of the possible determinants of alliance performance.

Third, this research found that alliances emerge out of weak or no ties as well as strong ties. It is certain, as the embeddedness approach implies, that organizations do build interorganizational networks on embedded ties. However, it is not always so. Organizations may have different values about the role of social ties in running a business and place different emphasis on the embedded ties. This finding of different levels of tie strength in alliance origins also suggests a new analytical dimension in

examining relationships between economic activities and social relations and structures.

Fourth, this research added to previous research an examination of what exactly organizations learn and how the learning is useful in selecting alliance partners. It proposes that organizational learning is a process in which organizations, groups in organizations and organizational members create and improve routines and that routines developed through the accumulation of alliance experience are the assessment methods for prospective partners. Learning frequently happens at the individual level and results in development of the BD professionals' intuition and skill. In addition, an interview case reveals that learning also takes place at the organizational level and contributes to the creation of formal assessment methods for due-diligence processes. By pointing out a possible linkage between the intraorganizational characteristics and the inter-organizational phenomena, this research suggests that interorganizational relations research should not overlook intraorganizational processes and structures that may generate specific patterns of interorganizational relations.

Fifth, as opposed to previous research, this study did not find strong evidence for the contribution uncertainty. It seems that idiosyncratic industrial characteristics set presumed levels of trust and, thereby, reduce the contribution uncertainty at the industry level. Another possible reason for this weak finding is that most of the interviewees are BD professionals whose roles are limited to the initiation and formation of alliances, rather than actual collaboration with partners in alliances. Because trust is crucial for exchanging information and sharing knowledge in alliances (Dyer & Singh, 1998; Ring & Van de Ven, 1993), it is reasonable to expect that their

limited responsibilities and involvement lead them to overlook issues of trust and malfeasance in selecting alliance partners. Furthermore, the BD professionals did not raise a concern about opportunism as frequently as expected because trust is something that can be developed even after alliance formation along with collaborative activities (Ring & Van de Ven, 1993), so that they focus more on prospective partners' technical competence in forming alliances.

Sixth, Stuart et al. (1999) found that it is crucial, particularly for entrepreneurial firms, to elicit approaches from and form alliances with prominent organizations for procuring endorsements and increasing growth and survival rates. This research implies a strategy for such organizations to form endorsement alliances, helping the prominent organizations reduce selection uncertainty by activating their relational and contextual mechanism. For instance, it may be an effective tactic to explore and cultivate social networks by sending scientists and BD professionals to conferences and industrial meetings. The investment in networking and social capital enables them to signal their technical competence to the environment, promote their presence in the industry, and increase the likelihood of being scanned and identified as prospective partners by prominent organizations. Alternatively, they are also able to signal their own credibility through such methods as publications in scientific journals, patent issues, scientific presentations at conferences, and presentations at business meetings. Having no influence over the prominent organizations' internal mechanisms, the entrepreneurial firms are able to activate their relational and contextual mechanisms and increase the likelihood of forming endorsement alliances.

Regardless of these contributions, however, this research so far has left two important questions unexplored. Although it has identified the 3 uncertainty reduction

mechanisms, it has considered them to be independent of one another. An examination of the complex relationships between different uncertainty reduction mechanisms began to appear in organization-theory literature during the 1960s, when the open-system approach was proposed (Katz & Kahn, 1966; Stinchcombe, 1990). Organizations generally have more than a single mechanism to manage environmental turbulence and reduce uncertainty. Interrelatedness of the mechanisms creates a number of internal organizational phenomena: (1) rules and programs, (2) schedules, (3) buffering and boundary spanning, (4) decentralization, (5) departmentalization and structural differentiation, and (6) lateral connections between subunits (Galbraith, 1973; Lawrence & Lorsch, 1967; March & Simon, 1957; Thompson, 1967). For instance, Galbraith (1973) views environmental uncertainty as the number of "exceptions" and contends that two fundamental strategies are available for organizations to reduce it: (1) reducing the need for information processing and (2) increasing the capacity to process information. While the former is aimed at reducing the number of "exceptions" and the amount of information to be processed by creating slack resources and promoting decentralization, the latter is to increase the organizational capability to handle more information by investing in vertical information systems and facilitating coordination of lateral connections between subunits.

In addition to these internal efforts, organizations are able to handle environmental turbulence by changing their relations with other organizations and stabilizing resource inflows and outflows. Available strategies include (1) increasing bargaining power, (2) co-opting representatives of powerful external actors into decision-making processes, (3) mergers, (4) forming associations to stabilize the

political environment, and (5) creating and reinforcing connections with government (Davis et al., 1990; Davis & Powell, 1992; Pfeffer & Salancik, 1978; Thompson, 1967; Thompson & McEwen, 1958).

Given that organizations have more than a single strategy or mechanism to manage uncertainty and that complex interrelatedness between them creates interesting organizational phenomena of value to be analyzed, this research should not leave the 3 mechanisms for reducing selection uncertainty independent of one another. Therefore, by entangling relationships among the relational, internal, and contextual mechanisms and addressing questions of how the 3 mechanisms are interrelated and how organizations use them differently, this research moves now beyond previous research and my fieldwork, which considered them independent of one another.

This new research will make a certain contribution to the embeddedness literature by predicting organizational use of the relational mechanism in a process in which I examine the interrelatedness. The approach was originally designed as an academic program that claims the importance of social relations and structures in executing economic transactions (Granovetter, 1985). However, recent efforts are aimed at treating embeddedness as a variable and accounting for its variance (Block, 1990; Uzzi, 1996, 1999). It is presumed in this emerging scheme that every firm places different values on social ties and uses them differently in running a business and that the variance affects the economic performance of organizations (Uzzi, 1996, 1999). By claiming that one way of operationalizing organizational embeddedness is to observe the social origin of alliances and take the relational mechanism as the dependent variable, this research will contribute indirectly to the emerging research agenda in economic sociology by adding knowledge about factors that account for

sources of variance in how organizations use ties in initiating alliance formation processes.

In addition to the interrelatedness issue, while it has briefly discussed the fact that bounded rationality restricts the organizational capability to predict all future contingencies and completely resolve selection uncertainty, this research so far has left unexplored the associations between the uncertainty reduction mechanisms and alliance performance. In the following, I will focus on the effects of the relational mechanism on alliance performance because one of the current theoretical agendas is to account for whether, and to what extent, embedded nature of economic behavior influences economic performance (Uzzi, 1996, 1999; Gulati, 1998). Gulati (1998) notes that "while there have been several efforts to explore differences in 'embedded' ties between firms and those that are less proximate, they tend to infer and don't directly assess whether embedded ties themselves perform any better than other ties." Since the relational mechanism refers to organizational usage of pre-existing personal rapport and ties in reducing selection uncertainty and forming alliances, it is reasonable to suppose that predicting alliance performance with the relational mechanism would enable me not only to highlight an effect of one of the uncertainty reduction mechanisms, but also to respond to this emerging research agenda.

In short, while it was found that organizations use the 3 mechanisms in reducing selection uncertainty and forming alliances, the two important questions remain intact: (1) interrelatedness among the mechanisms and (2) effects of the relational mechanism on alliance performance. In the following chapter, I will develop several hypotheses and present results from both archival and mail-survey data to answer the first and second questions respectively.

In this chapter I presented findings in the fieldwork as well as reviews of previous research. As a result of these efforts, I identified the three uncertainty reduction mechanisms and answered questions as to how organizations reduce selection uncertainty and what mechanisms enable organizations to do so. I also argued that bounded rationality makes it impossible for organizations to resolve selection uncertainty completely prior to alliance formation and that this impossibility often results in unsatisfactory outcomes of alliances. In addition, as the next task of this research, I proposed two new research questions for the following chapters: (1) how these uncertainty reduction mechanisms are interrelated and (2) how use and activation of the relational mechanism influence alliance performance. Both questions are aimed at enriching our understanding not only of organizational management of uncertainty in general, but also of the embeddedness literature that asserts the importance of concrete social ties and shared history of interactions in conducting economic transactions.

CHAPTER FOUR: MODELS

In this chapter I provide the model and construct hypotheses to answer the second set of research questions: (1) how the 3 uncertainty reduction mechanism are interrelated and (2) how use and activation of the relational mechanism influence alliance performance. I propose 4 hypotheses for the former and 2 hypotheses for the latter.

4-1: Hypotheses on Interrelatedness

The first part of this chapter proposes the model that hypothesizes the inter-relatedness of the 3 uncertainty reduction mechanisms with a focus on predicting organizational use of the relational mechanism. Activation of the relational mechanism means that organizations employ pre-existing and ongoing social ties in reducing selection uncertainty and forming alliances. While some organizations tend to form alliances with those to whom they are closely connected and with whom they have long history of interaction, others may make cold calls in initiating alliance formation processes with those having no prior interactions. For instance, while firm X formed an alliance with a repeated partner with which it actually had interlocking ties, firm Y formed an alliance with a foreign partner with which there existed no prior connections. This research captures and depicts this variance and activation of the relational mechanism by using a concept of multiplexity (Stuart, 1991; Wasserman & Faust, 1994) with alliance partners prior to alliance formation and, empirically, the number of prior organizational connections with alliance partners. In the network-analysis literature, multiplexity is originally defined as "the number of separate contacts which make up the relationships" (Stuart, 1991: 68). In this research context, multiplexity means levels of sharedness and interorganizational interactions with

partners prior to alliance formation. In other words, it depicts prior closeness and connectedness. It is presumed in the following argument that when there exists a higher degree of multiplexity at time *t-1* between two allying organizations, the focal firm uses the pre-existing ties and activates the relational mechanism when they form an alliance at time *t*. It must be noted that while multiplexity only describes the number of ties existing between two organizations, I presume that it also portrays use and activation of the relational mechanism. This assumption is crucial later in developing measures of the relational mechanism. The dependent variable in the following discussions is multiplexity, so I am going to develop hypotheses that predict why organizations form alliances with other organizations with which they have strong or weak multiplex pre-existing relationships.

The term *tie strength* should be reserved for a situation in which we observe "a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie" at the individual level (Granovetter, 1973: 1361). Although multiplexity is empirically different from tie strength, it is reasonable to presume that previous literature on tie strength provides a most compelling guide in predicting multiplexity and constructing hypotheses, for both constructs capture closeness and connectedness between two actors, either organizations or individuals.

As summarized in Table 4-1, previous research uncovered general characteristics of weak and strong ties (Burt, 1992; Granovetter, 1973, 1974, 1982; Hanssen, 1999; Krachhardt, 1992; Krackhardt & Stern, 1988; Powell et al., 1999; Stuart & Podolny, 1999; Uzzi, 1996). On the one hand, weak ties are built upon heterogeneous actors whose social contacts and profiles are dissimilar.

Table 4-1: Characteristics of Weak and Strong Ties

	Weak Ties	Strong Ties
Heterogeneity of Actors (Profile and Social Contacts)	More	Less
Information Redundancy	Less	More
Opportunity and Variety of Accessibility to Information and Resources	More	Less
Motivation to Be Assistant	Weaker	Stronger
Know Each Other	Less	More
Source of Information about Sources and Availability of Resources	Less	More
Trust between Actors	Weaker	Stronger

The heterogeneity in weak ties decreases the redundancy of information flowing in networks and provides accessibility to various information and resources. Granovetter (1973, 1974) finds that successful job seekers use weak ties for their searches, and that strong ties are less useful as a source of information about job openings. This situation arises because information from strong ties tends to be material that the parties already know and because weak ties provide information that they do not have but need. Uzzi's (1996) study of network organizations in the New York fashion industry also provides support for the validity of the weak tie argument. He finds that when organizations become too dependent on, and embedded in, other specific organizations, incoming information becomes more homogeneous, so that they are less likely to adapt to a changing environment and more likely to fail. Weak tie advantages lie in increasing opportunities to gain new information and in facilitating resource mobilization.

On the other hand, strong ties have some positive value. Actors connected strongly know each other and each others' situation in depth (Granovetter, 1973, 1974, 1982; Krachhardt & Stern, 1988). They know what the others know, what resources the others have, and what they can and cannot exchange with each other. This knowledge is crucial because it helps smooth exchange. For instance, Provan and Sebastian (1998) find, in their analysis of networks of mental health agencies in three cities, that strong ties between organizational cliques in networks increase the effectiveness of overall networks. Actors in each clique who are connected strongly know what they can provide to other health agencies in networks, from whom they can obtain particular medical assistance and information, and to whom they should send patients with a particular disease that they cannot cure. Such strong connections

facilitate locating available resources and enable each agency in a network to provide a broad range of medical services to patients by collaborating. Podolny (1994) also finds that organizations tend to collaborate with others with whom they previously collaborated, particularly in more complex exchange. A reason for this tendency is that strong social ties, defined as shared previous collaboration history, suggest what previous partners can and cannot do, so that organizations are able to reduce the cost of searching and selecting prospective exchange partners. Strong social ties are enriched information ties that help organizations identify the location of resources for future economic exchange. This advantage of strong ties becomes more salient in selecting partners for exchange involving more complex, tacit, and latent resources such as scientific knowledge and technical know-how (Hard, 1994; Hanssen, 1999; Kunkle, 1995; Sorensen & Lovold, 1992). Understanding the contents of such resources requires shared frames of reference that emerge from frequent interactions in which strong social ties are more able to convey the information about the location of complex resources that is prerequisite for selecting exchange partners.

Another advantage of strong ties is that greater social bonds discourage malfeasance and opportunism (Nelson, 1989). Actors connected through strong ties interact with each other more frequently. Frequent interaction promotes norms of reciprocity in relations and creates trust (Gulati, 1995; Larson, 1992; Tsai & Ghosal, 1998). In serious exchange relations that involve investment and exchange of more-valuable resources, actors tend to use social bonds to discourage opportunism and choose those strongly connected as their exchange partners (Das & Teng, 1998; Dyer & Singh, 1998; Zucker et al., 1996).

I claim that organizations basically select organizations with weak multiplexity as R&D alliance partners because organizations pursue non-redundant knowledge, resources, and technologies from alliance partners to increase resource complementarity and overcome their own weaknesses with the partners' strengths (Oliver, 1990; Powell, 1990). Indeed, Stuart and Podolny (1999) find that the semiconductor firms that formed alliances with technologically less-divergent competitors are less able to deliver innovative output, because "when an alliance unites technologically similar organization, it represents the proverbial 'redundant tie': a connection between two actors who possess the same information" (166).

However, selecting organizations with weak multiplexity as partners poses a greater degree of selection uncertainty. Two organizations having weak multiplexity possess less information about each other than do those having high multiplexity. This may cause adverse selection and increases uncertainty about partners' technical competence. In addition, when two organizations have weak multiplexity, the members are more likely to behave opportunistically toward one another, which produces moral hazard and increases uncertainty about partners' contributions. Forming alliances with organizations with weak multiplexity is more effective in resolving the information-redundancy problem but less effective in resolving selection uncertainty.

In order for organizations to form alliances with organizations with weak multiplexity, they may need to develop mechanisms or procedures to reduce selection uncertainty. The role of the relational mechanism should be replaced by other alternative mechanisms so that organizations are able to reduce selection uncertainty and form alliances with organizations with weak multiplexity without the help of the

relational mechanism. I believe that it is the internal and contextual mechanisms that enable organizations to resolve selection uncertainty problems in weak multiplexity networks and the information redundancy problem in high multiplexity networks. In other words, these two alternative mechanisms allow organizations to reduce selection uncertainty and form alliances without reliance multiplexity, so as to increase accessibility to heterogeneous resources and technology in organizational space. Organizations form alliances with organizations with weak multiplexity when they have the alternative mechanisms to reduce selection uncertainty. On the basis of these arguments, I propose the following hypotheses (see also Figure 4-1(:

H1: Organizations with more collaborative know-how are less likely to rely upon the relational mechanism in reducing selection uncertainty. As the organization develops collaborative know-how, the multiplexity will decrease.

H2: Organizations with higher degree of boundary-spanning activity are less likely to rely upon the relational mechanism in reducing selection uncertainty. As the organization conducts a higher degree of boundary-spanning activities, the multiplexity will decrease.

H3: Organizations with more technical intensity are less likely to rely upon the relational mechanism in reducing selection uncertainty. As the organization gains higher degree of technical intensity, the multiplexity will decrease.

H4: Organizations activating the contextual mechanism are less likely to rely upon the relational mechanism in reducing selection uncertainty. As the partner's reputation increases, the multiplexity will decrease.

4-2: Hypotheses on Alliance Performance

The second part of this chapter proposes the model of the effects of the relational mechanism on alliance performance. While performance of alliances has

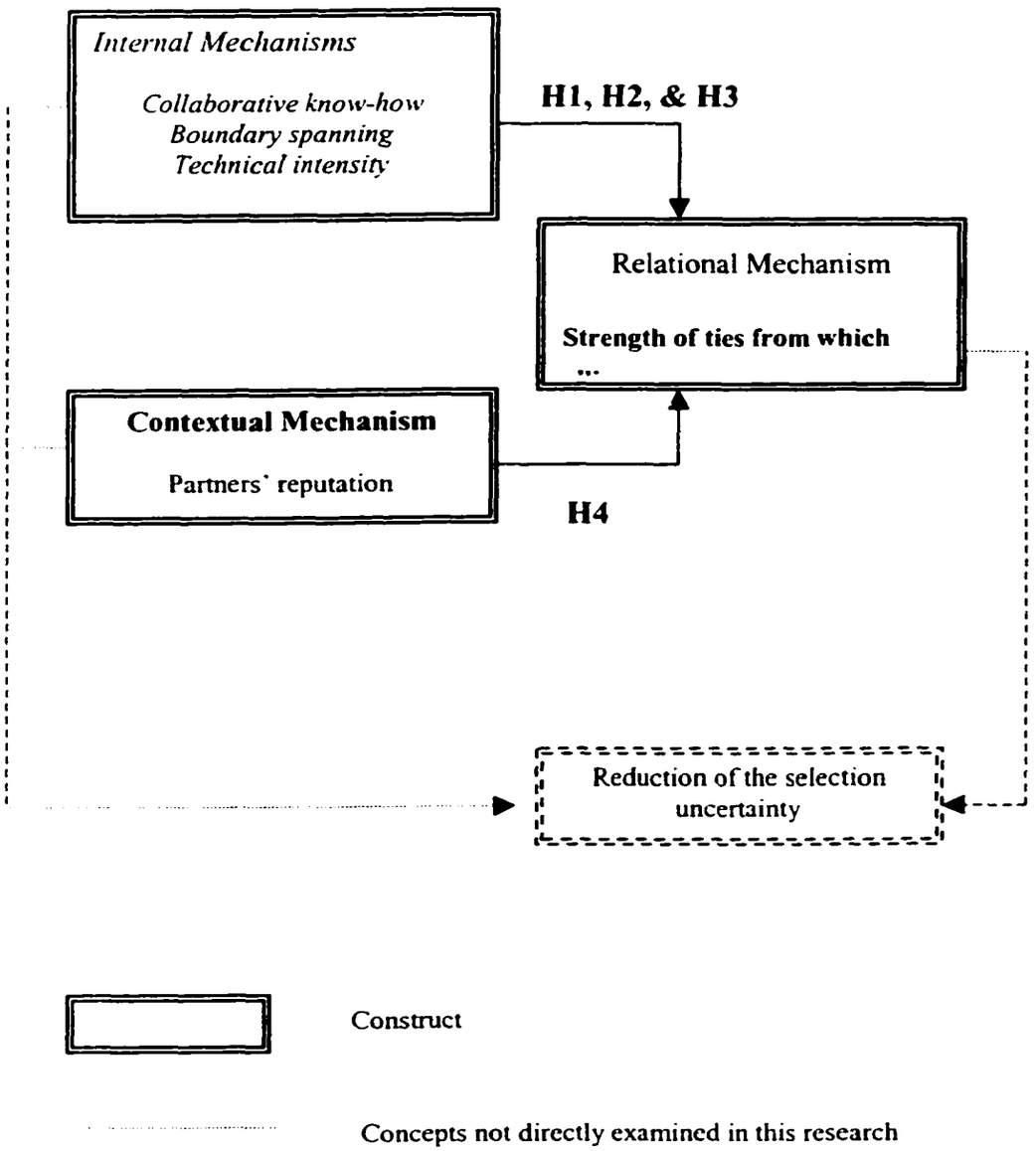


Figure 4-1: The Model of the Interrelatedness

been of great interest to researchers (Rogers & Mulford, 1982; Van de Ven & Ferry, 1980), it has been simultaneously one of the most controversial research areas in alliance literature (Gulati, 1998). An obvious reason for that is the lack of well-established definitions of alliance performance. The other evident reason is that it is hardly possible to collect financial, longitudinal, and overall rich data of alliance performance.

There are essentially 3 approaches to conceptualizing and operationalizing alliance performance, though none is complete: (1) by survival of alliances (Levinthal & Fichman, 1988; Seabright et al., 1988), (2) by the duration of collaboration (Baker et al., 1998; Barkema et al., 1997; Chowdbury, 1992), and (3) by managers' perception of alliance performance (Saxton, 1997; Simonin, 1997). In the first and second approaches, it is presumed that alliances achieving higher performance should last longer and survive better. However, the presumption does not recognize distinctions between natural death of alliances (i.e., a project has been successfully completed within in a very short period) and death caused by poor performance (Gulati, 1998). In addition, organizations may originally create some alliances only for short-term purposes (e.g., alliances for pre-clinical studies).

The third approach, perceived performance, also contains at least 2 problems in addition to traditional concerns for accuracy and reliability of perceived indicators of performance (Hunter & Schmidt, 1990; Nunnally, 1978; Starbuck & Mezias, 1996; Schwab, 1980). The first problem is that although researchers need to collect data from both allying organizations, it is hard to obtain such complete and large data sets (Rogers & Whetten, 1982). Even though the data are available, reasonable research methods have not been developed yet to deal with discrepancies and disagreements

between raters in different organizations about performance of the same alliance (e.g., Wright et al., 1998). The second problem is that perceived performance is highly influenced by raters' positions in their organizations. While senior managers, whose responsibility for alliances is limited once collaboration is initiated, tend to view collaboration positively, engineers, scientists, and researchers who actually collaborate and work with partnering organizations tend to perceive it negatively (Sobero & Schrader, 1998). While it is often the case that researchers rely upon a single rater's perception of alliance performance, this increases the risk of misrepresentation.

Regardless of these disadvantages, I am going to use the third approach, perceived performance, and define alliance performance for the sake of this research as "the extent to which the involved parties perceive each organization ('agency' in original) to carry out its commitments and judge the relationship to be worthwhile, productive and satisfying" (Van de Ven & Ferry, 1980: 327).

I chose it for the following three reasons. First, in general, research has found that measures of perceived organizational performance correlate with objective measures of performance (Brown & Perry, 1994; Dollinger & Golden, 1992; Powell, 1992). Second, one of the strengths of perceptual and survey data of interorganizational relations resides in easily generalized results. Whetten (1982: 103) notes that "because it is readily used in combination with various sampling techniques, the researcher is able to draw inferences to a larger population – hence survey research is extremely efficient." Third, in this research context, R&D alliances in the biotechnology industry, it is not unusual for one research project to require more than 10 years to be completed, and, as noted above, for an alliance not to deliver any commercial value right after alliance formation. In addition, some alliances are

formed only for short-term purposes and do not last long intentionally. Therefore, the two alternative traditional measures of alliance performance are not applicable in this context.

I make 2 opposing predictions about linkages between the relational mechanism and alliance performance. First, as I noted above, while the relational mechanism and high multiplex ties enable organizations to collect detailed, comprehensive, trustworthy, and timely information on prospective partners' technical competence and reliability, they also restrict flexible access to heterogeneous resources, knowledge, and information at the same time (Stuart & Podolny, 1999; Uzzi, 1996). It is reasonable to predict that limited access to heterogeneous and non-redundant resources and technology may restrict complementarity in alliances and thus decrease alliance performance. For instance, Saxton (1997) finds that repeated alliances are linked to initial satisfaction but not to long-term benefits to partners because it is less likely that organizations will find new resources, technology, and knowledge in repeated alliances, even though such alliances are easy to be maintained.

On the other hand, activation and use of the relational mechanism in forming alliances may restrict access to heterogeneous and non-redundant resources, knowledge, and information outside organizational boundaries (Burt, 1992; Granovetter, 1973). When two actors are strongly tied and multiplexed, they are more homogeneous in terms of social contacts and profiles and more likely to possess homogeneous resources and knowledge. Heterogeneity in weak ties, on the other hand, decreases the redundancy of information flowing in networks and provides accessibility to heterogeneous information and resources. Given that firms attempt to increase complementarity in alliances and procure non-redundant resources,

information, and knowledge by forming alliances, reliance on the relational mechanism that restricts access to heterogeneous resources and knowledge is detrimental. Saxton (1997), for instance, finds that, when firms that formed alliances previously re-engage in an alliance, perceived alliance performance decreases as time goes by. This is because while personal rapport opens up a communication channel at the initial stage of alliances, the benefit is cancelled out when managers find out that partners have resources, knowledge, and information that they procured in prior alliances.

H5: When the organization activates the relational mechanism in forming the alliance, the alliance is more likely to achieve high performance.
H6: When the organization activates the relational mechanism in forming the alliance, the alliance is less likely to achieve high performance.

In testing H1 to H4 on inter-relatedness, I collected and analyzed archival data (Study 1). In testing H5 and H6 on the relational mechanism and alliance performance, I collected data through mail surveys (Study 2). Although firms examined in both Study 1 and Study 2 are all publicly-held biopharmaceutical firms in the Untied States, the samples in the 2 studies are not identical.

I have so far proposed the first set of research questions and answered them with data obtained from the fieldwork. As a result of the fieldwork, the second set of research questions came up: (1) how the 3 uncertainty reduction mechanisms are interrelated and (2) how usage and activation of the relational mechanism influence alliance performance. In this chapter I have developed 6 hypotheses to answer this second set of research questions. I argue that organizations reduce their reliance on the relational mechanism, which is operationalized with multiplexity, when the

alternative reduction mechanism is available. This is because by doing so, organizations are able to expand their access to non-redundant and heterogeneous resources and knowledge at partnering organizations. In addition, I hypothesize that use of the relational mechanism can either increase or decrease alliance performance. On the one hand, reliance on the relational mechanism may restrict organizational access to non-redundant and heterogeneous resources and knowledge outside organizational boundaries. On the other hand, the relational mechanism enables organizations to transfer behavioral expectations and norms of reciprocity developed from prior interactions so that they are less likely to face an issue of partners' malfeasance and opportunism along with a course of collaboration. I will test H1 to H3 with archival data (Chapters 5 and 6) and H5 to H6 with mail-survey data (Chapters 7 and 8).

CHAPTER FIVE: METHODS – STUDY 1

In this chapter I provide the methodology for Study 1, aimed at testing H1 – H4 on interrelatedness among the three uncertainty reduction mechanisms with archival data.

5-1: Sample

The unit of analysis in this research is an alliance. The approach I employed in testing hypotheses is an organization-set (or the focal organization), or egocentric network analysis, in which I essentially focused upon relationships between the focal organization and other organizations connected with it (Ferry & Van de Ven, 1980; Hall, 1982; Knoke & Kuklinski, 1980; Stern, 1978)[3].

The sample consists of 145 R&D alliances formed by 48 biotechnology firms publicly held in the U.S. stock market with other U.S. publicly-held biotechnology and pharmaceutical firms from 1995 to 1999. I excluded licensing because it does not usually involve any form of scientists' interactions and collaboration. I identified 297 publicly-held biotechnology firms in *Recombinant Capital Biotechnology Alliance Database* (ReCap), *Corporate Directory of Technology Companies*, *Windhover's Healthcare Strategists*, and *Standard & Poors' Compustat*. I conducted the

[3] One may wonder whether there can be an alternative analytical approach such as a complete network analysis (Knoke & Kuklinski, 1980). It is certain that this method is a powerful tool for studying "interorganizational activity in many parts of a system, not just at one particular focal point" (Stern, 1979: 243) and for comprehending "patterns of relationships among an identifiable cluster of organizations bound together by allied domains, geographically, target / client organizations, or problems" (Van de Ven & Ferry, 1980: 299). However, one of my research interests here is how internal resources and capabilities such as collaborative know-how influence formation of alliances and creation of interorganizational networks. The egocentric network analysis, or the organization-set analysis, seems to be more appropriate for this research goal because the analysis is useful for examining the manner in which organizational characteristics are related to interorganizational patterns and for tracing interactions between intraorganizational capabilities and the network of organizations in its environment (Evans, 1966; Hall, 1982; Klonglan et al., 1976; Provan et al., 1980; Terrebery, 1968).

proportional stratified sampling (Sedlack & Stanley, 1992) on the basis of the 1999 asset size and extracted 88 of the 297 firms, approximately 30%. I ran independent-samples t-tests and did not find significant differences in asset size between the firms extracted and those left out (results are not shown).

I then identified R&D alliances formed by the 88 firms from 1995 to 1999 with Recap and *Windhover's Healthcare Strategists*. Fourty firms were removed from the analysis because they did not form alliances with other publicly-held U.S. firms. I did not remove 4 redundant-alliance cases in order to examine effects of organizational-level variables on alliance formation. I used the 1995-1999 observation window because, as noted above, the industry and its environment prior to 1995 are thought to be different in terms of presence of established pharmaceutical firms in the market. On average, these 48 firms formed .60 R&D alliances per year from 1995 to 1999. The firm in my sample that formed the most alliances during this period was Aurora Biosciences (9 alliances). The 16 firms formed only one alliance during this period.

5-2: Dependent Variable (Multiplexity)

It is important to note that there is a fundamental assumption in constructing measures and testing hypotheses with archival data: firms are presumed to use and activate uncertainty reduction mechanisms when they have a chance to do so. For instance, as will be discussed below, one of the measurement components of the relational mechanism is the presence of interlocking ties between allying firms. When firms have interlocking ties at time *t-1* and form an alliance at time *t*, it is presumed that they use interlocking ties in initiating alliance formation processes and rely on these ties as the relational mechanism for reducing selection uncertainty. When a firm has a greater degree of collaborative know-how, it is presumed that the firm uses its

internal capabilities in reducing selection uncertainty. Although it is actually ambiguous whether or not organizations always activate the mechanisms whenever they have a chance to do so, I followed Gulati and Westphal (1999) and Nohria (1992) and presumed this close linkage between organizational attributions and actual activation of the mechanisms.

As discussed above, multiplexity is a proxy to the relational mechanism and defined in this research as levels of sharedness and interorganizational interactions with alliance partners prior to alliance formation. I constructed the measure of multiplexity with the following dummy indicators in measuring to what extent two allying organizations have a shared history of interactions, show higher levels of sharedness, demonstrate a higher degree of closeness, and possess high multiplexity: (1) presence of *direct interlocking* at time *t-1* between firms (Burt, 1980; Davis and Greve, 1997; Mizruchi, 1996; Palmer, 1983), (2) that of *indirect interlocking* at time *t-1* (Burt, 1980), (3) that of previous economic transactions (*repeated ties*) by time *t* (Gulati, 1995; Gulati & Singh, 1998), (4) that of shared *investor ties* at time *t-1* (Eccles & Crane, 1988; Nohria, 1992), and (5) that of *CEO social similarity* by time *t* (Larson, 1992; Saxenian, 1994; Uzzi, 1996) (see Table 5-1). Following findings in the fieldwork and previous research (Gulati & Gargiulo, 1999; Gulati & Singh, 1998; Larson, 1992; Uzzi, 1996), it is presumed here that when alliance partners are those with high multiplexity, the focal organization activates and uses the relational mechanism in forming alliances.

Direct and indirect interlocking ties indicate closeness or distance between organizations in terms of the compositions of the boards of directors. Direct interlocking ties occur "when a person affiliated with one organization sits on the

Table 5-1: Variables in Study 1

	Construct	Variable	Data Source
Dependent Variable (H1 – H4)	**Multiplexity**	*Direct interlocking* (1: yes; 0: no)	Proxy
		Indirect interlocking (1: yes; 0: no)	Proxy
		Repeated ties (1: yes; 0: no)	ReCap[1]
		Investor ties (1: yes; 0: no)	Proxy
		CEO social similarity (1: yes; 0: no)	Proxy / Biography and Genealogy
		Multiplexity (sum of the five variables above)	Computed
H1	**Collaborative know-how**	*R&D alliance experience*	ReCap
		IOR experience	ReCap
		Organizational age (at the point of alliance formation)	Prospectus or Biotechnology Directory
H2	**Boundary spanning**	*Business development* (1: yes; 0: no)	Proxy
H3	**Technical intensity**	*Technical intensity* = R&D expense divided (t-1) / asset (t-1)	S&P's Compustat
H4	**Reputation**	*Partner's reputation* = {(log (the number of academic publications from t-2 to t) + 0.1) + (log (the number of patent from t-2 to t))} / 2	Science Citation Index and The U.S. Patent and Trademark Office
Other Variables	**Large pharmaceutical partner**	*Large pharm partner* (1: yes; 0: no).	1995 Fortune 1000 and S&P's 500
	Research alliance	*Research alliance* (1: yes; 0: no).	ReCap
	Financial performance	*Stock price* at t-1	S&P's Compustat
	Alliances in the industry	*Population alliances* at t-1	ReCap
	Focal firm's reputation	*Organizational reputation* = {(log (the number of academic publications from t-2 to t) + 0.1) + (log (the number of patent from t-2 to t))} / 2	Science Citation Index and U.S. Patent and Trademark Office

Note 1: Recombinant Capital Biotechnology Alliance Database

board of directors of another organization" (Mizruchi, 1996: 271). Indirect interlocking occurs when board members from two separated organizations sit together on the board of another organization (Burt, 1980). The presence of such ties can indicate multiplexity between allying firms, because it has been reported that "the interlock does provide a conduit for information on each firm's environment and so has the potential to give establishments an 'inside' connection to those establishments reachable via the interlocks" (Burt, 1980; 565). Another reason is that a number of previous studies confirm the role of interlocking as an interorganizational communication mechanism (i.e. Davis, 1991; 1994). Indeed, I ran into three alliance cases in my fieldwork for which the firms initiated discussions of possibilities of alliances because they had known each other through the interlocking ties. I collected the direct and indirect interlocking data from the annual proxies and coded them as 1 when the focal organization had the interlocking ties with the partner.

I used repeated ties as the third indicator of multiplexity because previous business exchange and transactions directly denote a history of interorganizational interactions (Gulati, 1995; Gulati & Singh, 1998). I collected the data from ReCap and coded *repeated ties* as 1 when the focal organization had any previous business transaction with its partner prior to time t, including R&D alliances, licensing, supplying, manufacturing, asset purchases, and marketing agreements.

Moreover, I used another dummy variable that represents the presence of shared institutional investors between allying firms. It has been controversial to what extent institutional investors and venture capitalists are influential in business strategies and daily business operations. For instance, Kojima (1997) points out that the U.S. investment regulations restrict involvement of institutional investors in

corporate governance and courses of organizational actions. On the other hand, several studies on entrepreneurial firms report that venture capitalists, having diverse connections, provide information and make suggestions to help organizations build their networks (i.e. Nohria, 1992; Saxenian, 1994). I used this measure because I ran into two cases in which institutional investors played a role of the "network manager" and connected two separate firms with which they had investment relationships. I collected the data from the SEC filings and coded them as 1 when the focal organization shared the institutional investors or venture capitalists with its partner.

Furthermore, findings in Larson (1992) and Uzzi (1996) and those from my fieldwork imply that senior managers' social similarities in educational and professional profiles sometimes facilitate alliance formation. For instance, an alliance emerged from personal rapport between the chief scientific officers at two biotechnology firms who used to work for the same large pharmaceutical firm. The social similarities between senior managers are an indicator of multiplexity because the similarity creates personal rapport that forms shared framework of understanding and generates norms of reciprocity. Due to the availability of data, I focused only upon CEOs' social similarities and coded data from the proxies and *Biography and Genealogy Master Index* as 1 when the focal organization's CEO had social similarities with the partner's CEO in terms of (1) education, (2) previous professional history, (3) membership in social and local development organizations, and (4) membership on executive boards of industrial associations.

Table 5-2 presents descriptive statistics, correlation, and frequency of these five dummy indicators. A potential problem resides in the fact that these five indicators are just slightly correlated. Even the highest coefficient is .35 between

Table 5-2: Descriptive Statistics, Correlations, and Frequencies of the Five Dummy Variables for *Multiplexity*

Variable	Mean	S.D.	Min.	Max.	1	2	3	4	5
1 *Direct interlocking*	.10	.30	0	1	1				
2 *Indirect interlocking*	.14	.35	0	1	.33	1			
3 *Repeated ties*	.10	.31	0	1	.13	.06	1		
4 *Investor ties*	.08	.27	0	1	.20	-.04	-.02	1	
5 *CEO social similarity*	.06	.23	0	1	.35	.15	.05	.09	1

Frequencies	Yes (1)	No (0)
1 *Direct interlocking*	14	131
2 *Indirect interlocking*	19	119
3 *Repeated ties*	15	130
4 *Investor ties*	11	127
5 *CEO social similarity*	8	136

direct interlocking and *CEO social similarity*. Moreover, two out of the ten coefficients are negative, though the absolute values are small. Although it is certain that this result raises a concern about validity and consistency of the measure, this may be because this measure captures different aspects of interorganizational ties and may not need to be highly correlated. For instance, interlocking ties and repeated ties highlight different aspects of relations between organizations in that although the former represents the relations only from the corporate-governance perspective, the latter indicates prior resource-exchange relations. Another problem to be noted is the small variance in and low frequencies of the five dummy variables. This small variance would cause the narrow "restriction of the range" problem in regression analyses, so I aggregated these five dummy indicators and created a new count variable, *multiplexity*, for the following regression analyses. This aggregated variable indicates overall strength of ties between allying firms.

5-3: Independent Variables

Collaborative know-how: I used three variables to examine effects of collaborative know-how: (1) *R&D alliance experience by t*, (2) *IOR* (interorganizational relations) *experience by t*, and (3) *organizational age* at time *t* (Burkema et al., 1997; Powell et al., 1996; Simonin, 1997). *R&D alliance experience* contains the count data that indicate the number of R&D alliances that the focal organization had formed prior to time *t*, which were collected from ReCap. I included research consortiums and R&D alliances with privately held firms, foreign firms, universities, and other research institutions (e.g., the National Institutes of Health) in constructing the data. *IOR experience* is another count variable that indicates the number of interorganizational deals that the focal organizations had made prior to time *t*, which were also collected

from ReCap. Such deals encompass licensing, supplying, manufacturing, asset purchases, and marketing agreements as well as R&D alliances. The third measure is *organizational age*. It is presumed here that older organizations have more experience in making interorganizational deals and managing inter-organizational relations (Powell et al., 1996). In addition to R&D alliances and the deals noted above, organizations may accumulate experience relevant to developing collaborative know-how through managing relationships with government agencies, universities, professional organizations, industrial associations, financial institutions, and consulting firms. I collected the age data from the *Biotechnology Directory* and the prospectuses.

Boundary spanning: I measured the effects of boundary spanning by the presence of senior BD executives on top management teams. While an absence of BD executives does not necessarily indicate the absence of BD professionals in organizations, it typically correlates with the size of the BD unit and its impact on strategy formation (Welbourne & Cyer, 1999). I collected information from the "Executive Compensation" section of each annual proxy and coded *BD executive* as 1 when the focal organization had a senior BD executive on its top management team.

Technical intensity: As noted above, technical intensity is typically measured as the proportion of expenditures on R&D activities to annual sales (Milkovich et al., 1991). However, this traditional measure is not appropriate for biotechnology firms because many of the biotechnology firms do not make any profit. Indeed, an average of the 1998 net income of 297 publicly-held biotechnology firms is – $4.19 billion. I constructed *technical intensity* at time t by dividing R&D expenditure at time $t-1$ by assets instead of sales at time $t-1$ to examine the effects of R&D investment relative to

firms' size and substantial performance. I collected the data from Standard & Poors' Compustat.

Partner's reputation: In operationalizing the contextual mechanism, I collected partners' publication and patent data. In the biotechnology industry, where scientific research and knowledge creation are highly valued, scientific contribution and intellectual property are crucial for organizational growth and survival (Barry et al., 1992; Ryan et al., 1995). First, I used the Science Citation Index Database and collected the number of academic publications by partners from time *t-2* to *t*. I then used the U.S. Patent and Trademark Office Database and collected the number of commercial patents by partners from time *t-2* to *t*. Although it is more desirable to incorporate the number of times papers or patents are cited in assessing the impact of the works on the industry and reputation of firms (Latour, 1987; Stuart, 1998), that is difficult to accomplish because in the biotechnology industry each firm has unique technology and tends to specialize in varieties of therapeutic fields and create scientific and commercial outputs for different sizes of markets.

These two variables, after log transformations, are highly correlated and related to each other: (1) r = .72 and (2) Cronbatch's alpha = .84. I therefore used means of the publication and patent data as *partner's reputation* in the following analysis[4].

[4] An alternative operationalization of the contextual variable is available in Podolny (1994), in which four interaction variables were are: (1) the focal firm's reputation score when the the focal firm's score is greater than the partner's score, (2) the focal firm's score when the focal firm's score is less than the partner's score, (3) the partner's score when the partner's score is greater than the focal firm's score, and (4) the partner's score when the partner's score is less than the focal firm's score (see also Johnston, 1984). However, because I am interested in whether or not partners' reputations help the focal organizations reduce selection uncertainty without reliance on the relational mechanism, I used the simple reputation scores of the partners as an independent variable and those of the focal firm as a control variable (see below).

Other Variables: I included five control variables considered to be relevant. The first control variable indicates whether or not the partner is a large pharmaceutical firm. R&D alliances with large pharmaceutical firms typically take a form of research outsourcing in which biotechnology firms conduct farmed-out research projects for pharmaceutical firms in return for cash payments. Because it is not biotechnology but pharmaceutical firms that need to ensure prospective partners' technical competence and reliability, such factors relating to biotechnology firms' internal capabilities and structures are less relevant in the biotechnology-pharmaceutical alliances. I collected the vital data from 1995 Fortune 500 and Standard & Poors' 500 Pharmaceutical Firm List and coded the 18 firms in my data set as the large pharmaceutical firms (see Appendix 4-1).

The second control variable is whether or not an alliance involves research activities, a proxy to the degree of intensity and interaction in alliances. In this research context, alliances involving research activities upstream of drug-discovery processes require more interaction and task interdependence between organizations (Pharmaceutical Research and Manufacturers of America, 1999; Standard & Poors', 1999; Windhover, 1997). It is reasonable to expect that the degree of required interaction between firms may have various effects on the procedures of alliance formation and the governance form of alliances. For instance, Gulati and Singh (1998) find that alliances that involve more interaction and more coordination tend to take a hierarchy-oriented governance form because this governance form, built upon command structure, authority systems, and standard operating procedures, is more capable in coordinating interactive work and interdependent tasks (Stinchcombe,

1985; Thompson, 1967). I collected the data from ReCap and coded *research alliance* as 1 when the alliance involved research activities.

The third control variable is the firm's financial performance measured by its year-end stock price at time *t-1* from *Compustat*. As noted in Chapter 2, most of the U.S. biotechnology firms are currently in the red. Their stock prices are more able to capture financial performance than are net profit and return on equity (ROE), because stock prices reflect evaluation of specialized investors who are knowledgeable about complex technology and the industry dynamism (Welbourne & Cyer, 1999).

The fourth control variable is the total number of alliances in the entire biotechnology industry at time *t-1*. The data contain (1) both biotechnology-biotechnology and biotechnology-pharmaceutical alliances, (2) both domestic and international alliances, and (3) alliances of both privately- and publicly-held firms. I collected the industry-level data from ReCap.

The last control variable is *organizational reputation*, which indicates the focal firm's reputation. Being analogous to partner's reputation, this variable consists of count data on publications from the Science Citation Index and patents from the U.S. Patent and Trademark Office Database. After log transformation, I took the means of these two data, which are relatively highly correlated and related with each other (r = .59; alpha = .74).

CHAPTER SIX: RESULTS – STUDY 1

In this chapter I provide theb results of statistical analyses for Study 1 aimed at testing H1 – H4 on inter-relatedness among the three uncertainty mechanisms with archival data. I employed a simple x^2 test for testing independence of the relational and internal mechanisms and ran negative binomial regressions for general hypothesis testing. I also examined associations between the internal and contextual mechanisms as an exploratory analysis. Two of the major findings in this statistical analysis are (1) organizations with a higher degree of collaborative know-how are less likely to form alliances with other organizations with a higher degree of multiplexity and rely upon the relational mechanism in reducing selection uncertainty and (2) organizations with a higher degree of collaborative know-how are less likely to form alliances with other organizations with higher degree of reputation and rely upon the contextual mechanism in reducing selection uncertainty. Finally, I provide interpretations of findings, limitations, and directions for future research.

6-1: Results of Analyses

Table 6-1 reports correlations and descriptive statistics for the variables used in Study 1. Figures 6-1 to 6-5 graph associations of the 5 variables for *tie strength* with the three independent variables that indicate degree of collaborative know-how[5]. If collaborative know-how reduces organizational reliance on social ties in reducing selection uncertainty, as stated in H1, all the graphs should show the inverse-S shapes: more collaborative know-how should result in less use of any of the ties.

5

Some redundant plots are not printed so the 145 observations may not be found in every graph.

Table 6-1: Descriptive Statistics , Correlations, and Frequency of the Variables in Study 1[1]

		Mean	S.D.	1	2	3	4	5	6
1	*Multiplexity*	.48	.83	1					
2	*Equity alliance*	.20	.40	.33	1				
3	*R&D experience*	11.52	9.27	.08	-.01	1			
4	*IOR experience*	20.46	19.98	.10	.02	.95	1		
5	*Organizational age*	8.06	5.29	.14	.09	.40	.53	1	
6	*Business development*	.61	.49	.07	-.01	.30	.30	.10	1
7	*Technical intensity*	.38	.36	-.01	.23	-.12	-.18	.04	-.06
8	*Partner's Reputation*	3.61	2.86	-.08	.07	-.25	-.29	-.17	-.21
9	*Large pharm partner*	.34	.47	-.11	-.03	-.14	-.17	-.07	-.16
10	*Research alliance*	.59	.49	.11	-.11	.23	.12	-.18	.19
11	*Stock price*	17.79	20.95	.33	.07	.35	.39	.08	.18
12	*Population alliance*	58.85	21.27	-0.17	-.16	-.03	-.07	-.07	.22
13	*Organizational Reputation*	1.93	2.00	.02	.05	.60	.61	.21	.24

		7	8	9	10	11	12	13
1	*Multiplexity*							
2	*Equity alliance*							
3	*R&D experience*							
4	*IOR experience*							
5	*Organizational age*							
6	*Business development*							
7	*Technical intensity*	1						
8	*Partner's Reputation*	.25	1					
9	*Large pharm partner*	.13	.71	1				
10	*Research alliance*	-.11	-.09	.10	1			
11	*Stock price*	-.32	-.19	-.09	.18	1		
12	*Population alliance*	.19	.18	.18	-.04	-.19	1	
13	*Organizational Reputation*	-.26	-.13	-.08	.06	.33	-.01	1

Note 1: The number of observations is 145.

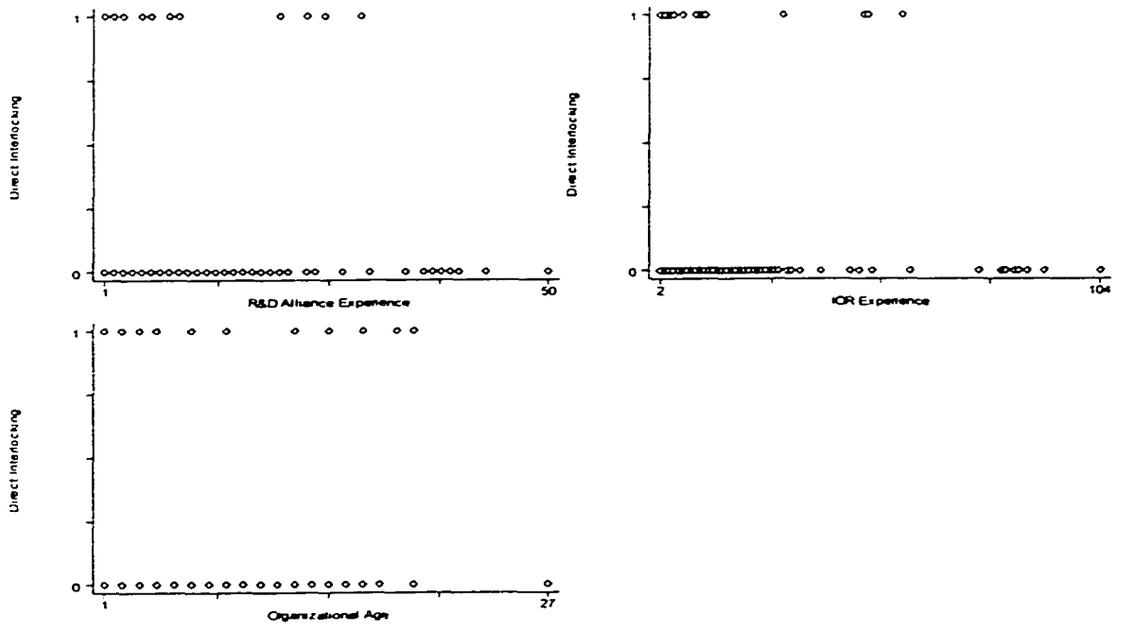


Figure 6-1: Direct Interlocking and Experience

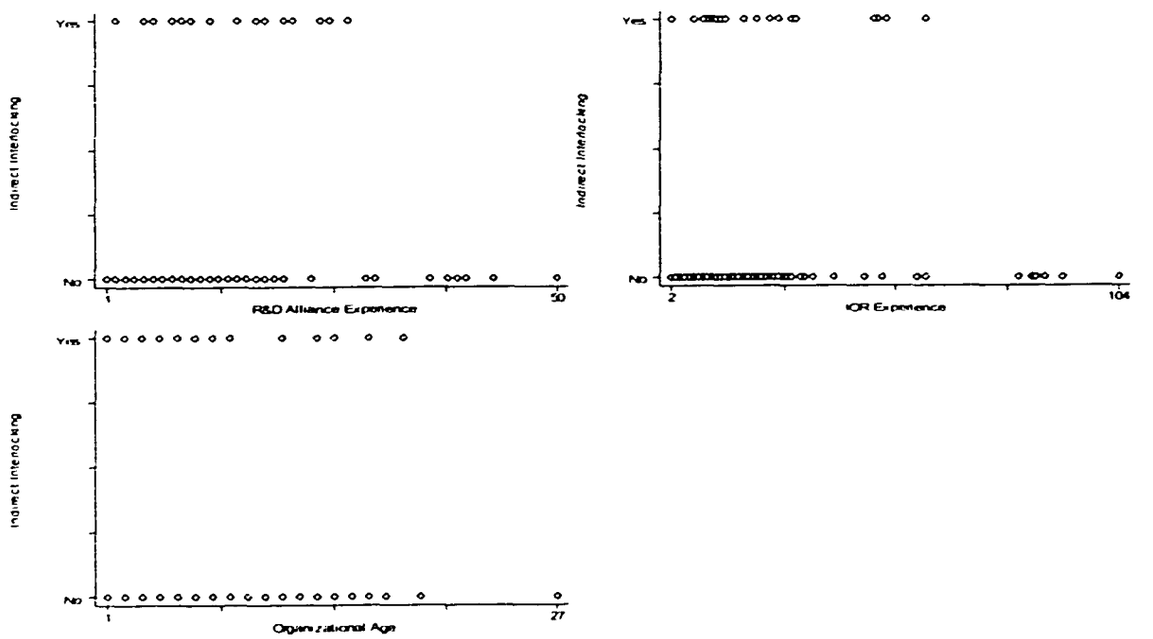


Figure 6-2: Indirect Interlocking and Experience

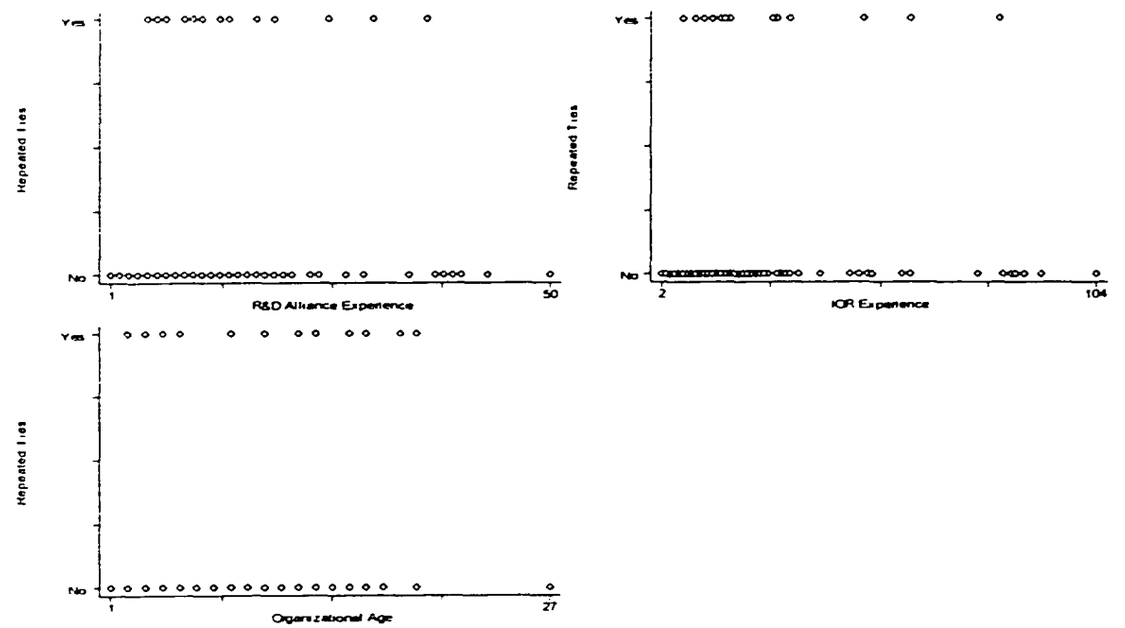


Figure 6-3: Repeated Ties and Experience

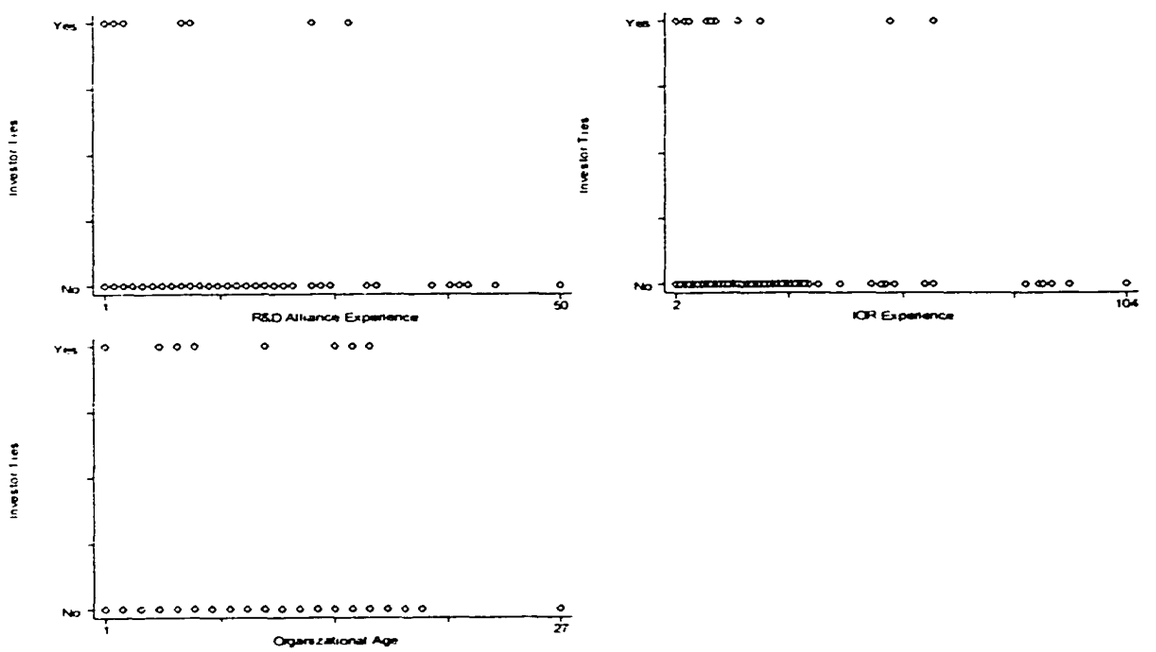


Figure 6-4: Investor ties and Experience

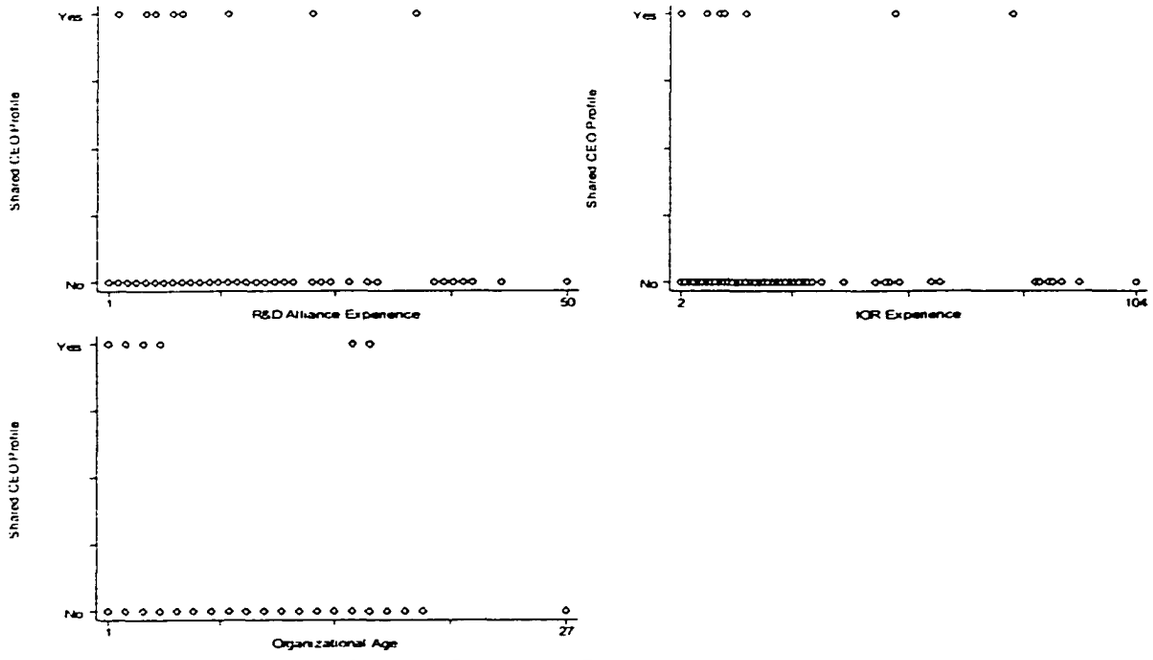


Figure 6-5: CEO Social Similarity and Experience

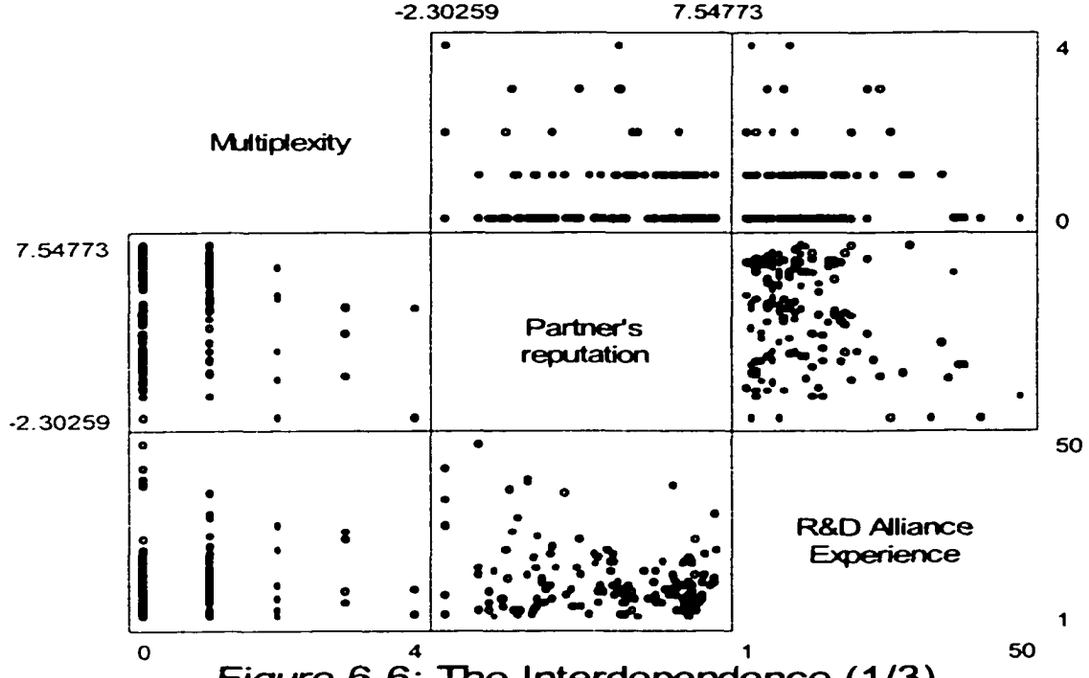


Figure 6-6: The Interdependence (1/3)

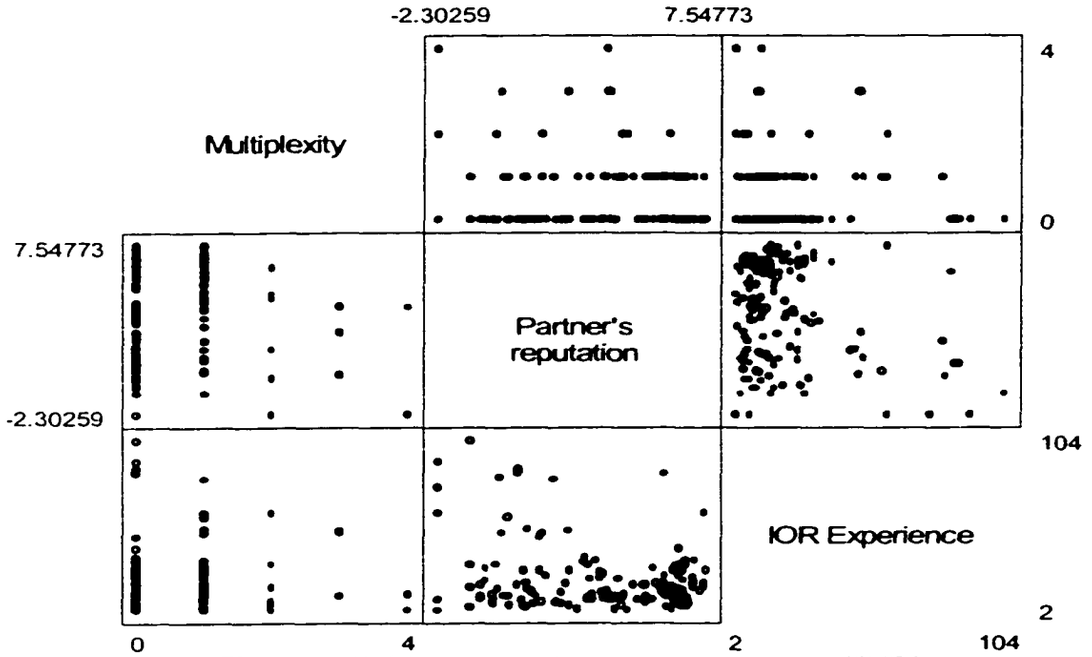


Figure 6-7: The Interdependence (2/3)

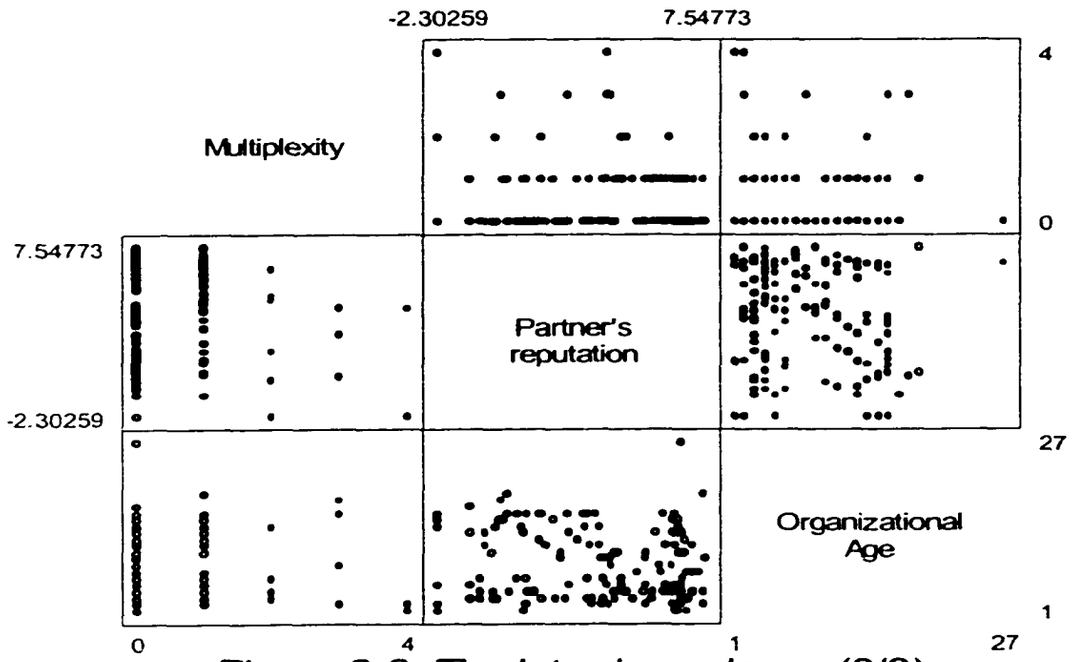


Figure 6-8: The Interdependence (3/3)

The visual inspections suggest possible weak or moderate associations between the two uncertainty reduction mechanisms. Figures 6-6 to 6-8, moreover, illustrate the interrelatedness among the three uncertainty reduction mechanisms. The top left in each graph is *multiplexity* between allying firms, which is a sum of the 5 variables, including (1) *direct interlocking*, (2) *indirect interlocking*, (3) *repeated ties*, (4) *investor ties*, and (5) *CEO social similarity*. The center in each graph is the *relative reputation index*, which contains factor scores of the *relative patent* and *publication indexes*. The bottom right is 3 different proxies to collaborative know-how and measures of alliance experience. In addition to possible associations of the relational mechanism with the contextual and, particularly, internal mechanisms, the visual inspections also suggest interrelatedness between the contextual and internal mechanisms: as organizations accumulate collaborative know-how, their alliance partners tend to be those with a relatively lower reputation. I will examine this potential association as an exploratory analysis later.

While an advantage of Figures 6-1 to 6-5 resides in a visual clue to the interrelatedness, they provide no statistical evidence on significance and strength of the interrelatedness and, hence, do not allow me to test H1. I created 3 new dummy variables for collaborative know-how with the median-split and constructed frequency tables in Table 6-2 that show 15 different combinations of the 5 multiplexity variables: (1) *direct interlocking*, (2) *indirect interlocking*, (3) *repeated ties*, (4) *investor ties*, and (5) *CEO social similarity*, and 3 variables of collaborative know-how: (1) *R&D alliance experience*, (2) *IOR experience*, and (3) *organizational age*. In other words, Table 6-2 is a summary of 15 different 2 x 2 tables of frequency counts along with

Table 6-2: Frequency Tables of Relationships between *Multiplexity* and Collaborative Know-how[1] (% of Frequencies in Parentheses)

		Multiplexity			
		Low		***High***	
R&D Experience	*Low*	Direct interlocking	59 (40.69)	Direct interlocking	9 (6.21)
		Indirect interlocking	59 (42.75)	Indirect interlocking	6 (4.35)
		Repeated tie	65 (44.83)	Repeated tie	3 (2.07)
		Investor tie	59 (42.75)	Investor tie	6 (4.35)
		CEO similarity	63 (43.75)	CEO similarity	4 (2.75)
	High	Direct interlocking	72 (49.66)	Direct interlocking	5 (3.45)
		Indirect interlocking	60 (43.48)	Indirect interlocking	13 (9.42)
		Repeated tie	65 (44.83)	Repeated tie	12 (8.28)
		Investor tie	68 (49.28)	Investor tie	5 (3.62)
		CEO similarity	73 (50.69)	CEO similarity	4 (2.78)

		Multiplexity			
		Low		***High***	
IOR Experience	*Low*	Direct interlocking	65 (44.83)	Direct interlocking	10 (6.90)
		Indirect interlocking	62 (44.93)	Indirect interlocking	9 (6.52)
		Repeated tie	70 (48.28)	Repeated tie	5 (3.45)
		Investor tie	64 (46.38)	Investor tie	7 (5.07)
		CEO similarity	70 (48.61)	CEO similarity	5 (3.47)
	High	Direct interlocking	66 (45.52)	Direct interlocking	4 (5.71)
		Indirect interlocking	57 (41.30)	Indirect interlocking	10 (7.25)
		Repeated tie	60 (41.38)	Repeated tie	10 (6.90)
		Investor tie	63 (45.65)	Investor tie	4 (2.90)
		CEO similarity	66 (45.83)	CEO similarity	3 (5.56)

		Multiplexity			
		Low		***High***	
Organizational Age	*Low*	Direct interlocking	66 (45.52)	Direct interlocking	8 (5.52)
		Indirect interlocking	62 (44.93)	Indirect interlocking	8 (5.80)
		Repeated tie	68 (46.90)	Repeated tie	6 (4.14)
		Investor tie	64 (46.93)	Investor tie	6 (4.35)
		CEO similarity	67 (46.53)	CEO similarity	6 (4.17)
	High	Direct interlocking	65 (44.83)	Direct interlocking	6 (4.14)
		Indirect interlocking	57 (41.30)	Indirect interlocking	11 (7.97)
		Repeated tie	62 (42.76)	Repeated tie	9 (6.21)
		Investor tie	63 (45.65)	Investor tie	5 (3.62)
		CEO similarity	69 (47.92)	CEO similarity	2 (2.82)

Note 1: The number of observation varies from 138 to 145.

various measures of the relational mechanism and collaborative know-how. If organizations with more alliance experience and more collaborative know-how are less likely to use the relational mechanism in reducing selection uncertainty, we should observe high frequencies at both the top left and bottom right cells in each subtable. In each sub-table, however, high frequencies in the bottom left cells and low frequencies in the bottom right cells are actually found; regardless of the degree of collaborative know-how, multiplexity between the focal firms and their allying firms is weak. Indeed, except for the combination of R&D experience and repeated tie (x^2 = .8601, p = .027 in Appendix 6-1), I obtained no significant results in x^2 tests for each of the 14 different combinations, which suggests that the relational mechanism and collaborative know-how are independent. Although results of the x^2 tests did not lend support to H1, x^2 tests were restricted to examining the independence of associations between just two variables, so I could not provide decisive answers on H1 here.

Table 6-3 reports results of negative binomial regressions with random effect within-group correlation structures in which I examined effects of the internal and contextual mechanisms on the relational mechanism for testing H1 - 4. The dependent variable, *multiplexity*, is a nonnegative count variable (0 to 5). Negative binomial regressions are appropriate in this hypothesis testing because they enable us to examine variance of such dependent variables (Baum & Oliver, 1996; Stata, 1999). I did not use the poisson regression models, another regression model to predict variance of a count variable, because variance of the dependent variable (.83 in Table 6-1) is larger than its mean (.48 in Table 6-1), which causes the over-dispersion problem (Greene, 1997). I treated the data sets as "pseudo" unbalanced panel data, in

Table 6-3: Negative Binomial Regressions with Random Effect Within-group Correlation Structures: Dependent Variable = *Multiplexity*[1]

	A	B	C	D
R&D experience		.0129		
		(.0174)		
IOR experience			.0092	
			(.0073)	
Organizational age				.0332
				(.0207)
Business development		.0840	.0351	.0091
		(.2984)	(.2929)	(.2877)
Technical intensity		.3384	.3343	.2960
		(.3283)	(.3158)	(.3140)
Partner's Reputation		.1331 *	.1359 *	.1415 *
		(.0636)	(.0622)	(.0633)
Large pharm partner	-.1760	-.7105 *	-.7235 *	-.7675 *
	(.2829)	(.3698)	(.3713)	(.3766)
Research alliance	.1837	.1542	.1599	.2023
	(.2700)	(.2633)	(.2591)	(.2581)
Stock price	.0094 *	.0262 ***	.0255 ***	.0264 ***
	(.0042)	(.0068)	(.0067)	(.0067)
Population alliance	-.0057	-.0051	-.0045	-.0039
	(.0063)	(.0065)	(.0065)	(.0066)
Organizational Reputation	-.0486	-.1002	-.1172	-.0819
	(.0732)	(.0825)	(.0816)	(.0691)
Constant	-.9609 *	-1.9124 ***	-1.9293 ***	-2.1728 ***
	(.4366)	(.5493)	(.5460)	(.5792)
Wald x^2	13.50 **	32.85 ***	35.38 ***	37.54 ***
ρ	0.08	-0.04	-0.06	-0.06

Note 1: For the estimations I used the negative binomial function (k = 1), negative binomial link, and exchangeable correlation structures in Stata 6.0. I also used unstructured and autoregressive (AR1) within-group correlation for the estimations. Because outcomes are essentially identical across the various models, I do not show them.
Note 2: * $p < .05$; ** $p < .01$; *** $p < .001$; two tailed tests.
Note 3: Standard errors are in parentheses.

which a firm may have more than one entry in one year and no entry in another year. This data structure required me to deal with nonindependence of subjects and, in statistical terms, within-group correlation structures. Although running regressions with the 47-firm dummy and the 4-year dummy variables is an option,[6] I treated the data set as the "pseudo" panel data so as to reduce the number of parameters to be estimated. Because regression results with random effects and autoregressive (AR1) within-group correlation structures (Stata, 1999) are not significantly and crucially different, I show results only from the random-effect model in this research.

In Table 6-3, I report three significant findings. First, the focal firm's *stock price* is positively associated with *multiplexity* with its allying firms: when the focal firm performs better, its partners tend to be those with higher *multiplexity* (i.e., $b = .03$, $p < .001$ in equation B). Second, I obtained the negative and significant coefficients of *large pharm partner* across the different models: when the focal firm forms R&D alliances with large pharmaceutical firms, *multiplexity* between them is weaker (i.e., $b = -.71$, $p < .05$ in equation B). This, in turn, means that allying firms tend to have higher *multiplexity* in the case of biotechnology-biotechnology alliances. Third, I found positive and significant effects of *partner's reputation* on *multiplexity* between allying firms: while *multiplexity* is weaker when the partners have low reputation scores, it is stronger when they have high reputation scores (i.e., $b = .13$, $p < .05$ in equation B).

The second finding did not lend a direct, but indirect, support to the hypotheses on inter-relatedness between the relational and internal mechanisms (H1-H3), though I

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[6] These are often called the fixed-effect models and are actually used in Gulati and Gargiulo (1999).

should not over-emphasize the following interpretations because non-significant findings as to *R&D experience*, *IOR experience*, *organizational age*, *business development*, and *technical intensity*. As noted above, in biotechnology-pharmaceutical alliances, which often take the form of research outsourcing, it is pharmaceutical firms that assess technical competence and reliability of biotechnology firms and reduce selection uncertainty in forming alliances. The finding from Table 6-3 implies that large pharmaceutical firms are less likely to use the relational mechanism in reducing selection uncertainty because they, in general, accumulate more alliance experience, develop more collaborative know-how, and structure subunits dedicated to alliance formation. Furthermore, large pharmaceutical firms are more able to make a large-scale investment in their internal R&D activities, which results in increased levels of technical intensity. These internal mechanisms, therefore, enable them to decrease their reliance on the relational mechanism and decouple or de-embed economic transactions and interorganizational collaboration for gaining access to cutting-edge technology through social ties. Large pharmaceutical firms are able to form alliances with partners with weak multiplexity because of the internal mechanisms that replace the role of the relational mechanism in selecting alliance partners.

On the other hand, biotechnology-biotechnology alliances, which typically focus upon upstream research activities and require symmetric efforts to reduce selection uncertainty, tend to emerge out of multiplex ties. Biotechnology firms accumulate less alliance experience and possess fewer internal resources for boundary spanning and technical intensity. As a result, limited development of the internal mechanisms prevents them form gaining access to resources and technology outside of

their organizational boundaries without relying on currently available ties. Although regression results from Table 6-3, as well as x^2 tests in Table 6-2, did not provide direct and evident support for the interrelatedness between the relational and internal mechanisms (i.e., *b* of *R&D experience* = .01, p = .40), this finding provides some insights into potential processes in which the internal mechanisms replaces the role of previous interorganizational interactions in reducing selection uncertainty and forming alliances.

The third finding on *partner's reputation* in Table 6-3 provided negative support for H4, which hypothesizes that *multiplexity* should be weaker when partners' scores are higher. This hypothesis is incorrect in that, as the regression results show, multiplexity is higher when the partner has the higher reputation score. In turn, as the partners' reputation scores are lower, the multiplexity decreases.

Reputation determines the degree of difficulty in making contact and initiating alliance formation processes (Podolny, 1995; Stuart, 1998). It is less difficult for the focal firm with a high reputation to initiate the alliance formation processes with any other organizations, not only because its high reputation helps the prospective partners reduce selection uncertainty concerning the focal firm, but also because a number of firms are interested in obtaining endorsement through collaborating with reputable firms (Stuart et al., 1999). Furthermore, being known in the environment, which occasionally correlates with reputation, saves time and resources for the approached firms in identifying other approaching firms. Reputation is a ticket to constructing interorganizational networks without reliance on previous interactions and to gaining access to heterogeneous resources and technology at other organizations with no or weak multiplexity.

In turn, this result also connotes that organizations need certain previous interactions in order to form R&D alliances with highly reputable partners. Such previous interactions alleviate the contact problem arising from the fact that a number of organizations are interested in forming alliances for endorsement because the previous interactions increase familiarity and attentions from the prestigious organizations when contacted. This interpretation is consistent with a finding in the fieldwork that the BD professionals often look for internal personnel who know someone in prospective partners prior to the initial contact, because such ties increase priorities and attention of the prospective partners and facilitate the contact processes. This instrumental value of ties extends organizational ability to locate resources and technology at highly reputable organizations.

As noted above and illustrated in Figures 6-6 to 6-8, there seem to be negative associations between the internal and contextual mechanisms: as organizations develop the internal mechanisms, they are less likely to use the contextual mechanism in reducing selection uncertainty. In order to examine this potential interrelatedness, I conducted an exploratory analysis and ran 4 regressions with random effect within-group correlation structures (see Table 6-4). In principle, I predicted organizational use of the contextual mechanism, the *relative reputation indexes*, with the internal mechanisms and, particularly, collaborative know-how.

The first interesting finding in Table 6-4 is that coefficients of *IOR experience* and *alliance age*, proxies to collaborative know-how, are negative and significant (b = -.02, $p < .05$ in equation C, and b = - .09, $p < .01$ in equation D): as the focal firm

Table 6-4: Regressions with Random Effect Within-group Correlation Structures: Dependent Variable = *Partner's Reputation*

	A	B	C	D
R&D experience		-.0411		
		(.0247)		
IOR experience			-.0244 *	
			(.0106)	
Organizational age				-.0921 **
				(.0339)
Business development		-.3927	-.3923	-0.4471
		(.4059)	(.3921)	(.3781)
Technical intensity		.9673 *	.9600 *	1.0876 *
		(.4995)	(.4791)	(.4739)
Large pharm partner	4.0542 ***	3.9644 ***	3.9532 ***	4.0752 ***
	(.4054)	(.4195)	(.4168)	(.4072)
Research alliance	-.7308 *	-.4928	-.6192	-.8713 **
	(.3879)	(.3868)	(.3723)	(.3778)
Stock price	-.0211 *	-.0136	-.0099	-.0177 *
	(.0103)	(.0102)	(.0102)	(.0091)
Population alliance	.0021	.0031	.0025	.0006
	(.0086)	(.0086)	(.0085)	(.0084)
Organizational Reputation	-.0399	.0955	.1217	.0288
	(.1119)	(.1251)	(.1201)	(.0999)
Constant	2.9189 ***	2.7253 ***	2.7479 ***	3.5778 ***
	.6554	.6640	.6522	.7111
Wald x^2	117.58 ***	155.77 ***	176.54 ***	198.36 ***
ρ	.05	-.05	-.06	-.08

Note 1: For the estimations I used the gaussian function, identity link, and exchangeable correlation in Stata 6.0. I also used fixed effect, unstructured and autoregressive (AR1) within-group correlation structures for the estimations. Because outcomes are essentially identical across the various models, I do not show them.
Note 2: * $p < .05$; ** $p < .01$; *** $p < .001$; two tailed tests.
Note 3: Standard errors are in parentheses.

develops collaborative know-how, its partners become those of lower reputation. More-experienced organizations develop collaborative know-how that enables them to identify and select partners without relying upon reputation. On the other hand, organizations with less collaborative know-how and, hence, limited internal capability to reduce selection uncertainty use reputation in assessing technical competence and reliability of prospective partners. Although the contextual mechanism reduces selection uncertainty, one of its disadvantages is that firms with a higher reputation tend to be more established and do not always possess cutting-edge technology. Reliance on the contextual mechanism restricts organizational access to technology at entrepreneurial firms and firms with emerging technology that do not necessarily have better patent and publication records. The finding here implies that it is collaborative know-how that enables organizations to assess and select alliance partners without reliance on reputation and, probably, to gain fast access to cutting-edge technology for adapting to a dynamically changing environment and increasing their competitive advantage.

The second interesting finding is that coefficients of *technical intensity* are positive and significant: as the focal firm has a higher technical intensity, its allying firms tend to be those with a higher reputation (i.e. $b = .97$, $p < .05$ in the equation B). This finding is actually opposite to H3, which hypothesizes a contribution of technical intensity to reduction of selection uncertainty. In this research, technical intensity is measured by the relative amount of internal investment in R&D activities in relation to organizational size and substantial performance. Although this measure certainly indicates organizational capability to scan the environment and take over emerging technology, it also means future technological achievement and potential growth of

organizations, given a strong association between investment and innovation (Cohen & Levinthal, 1990). Higher technical intensity should signal to other firms in the environment a higher level of technological intensity, more focus on R&D activities, and more healthy investment in technological innovation and future growth. Organizations with higher technical intensity help other firms looking for partners to reduce selection uncertainty and create an image that appeals to organizations with a more established and, hence, higher reputation. The signaling effect of technical intensity may alleviate the difficulty of contacting reputable organizations and provide organizations with a lower reputation with a ticket to those with a higher reputation.

6-2: Discussions and Limitations

In short, Study 1 has provided the following 4 findings:

1. As the focal organization accumulates alliance experience and develops collaborative know-how, its partners tend to be those with weak multiplexity, because collaborative know-how reduces organizational reliance on previous interactions in reducing selection uncertainty and forming alliances.
2. As the focal organization accumulates alliance experience and develops collaborative know-how, its partners tend to be those with lower reputation, because collaborative know-how reduces organizational reliance on reputation in reducing selection uncertainty and forming alliances.
3. When partners have achieved a low reputation, the multiplexity is lower. When partners have achieved a high reputation, the multiplexity is higher. This is because reputation creates and alleviates the contact problem.
4. As the focal organization increases investment in internal R&D activities, its partners tend to be those with higher reputation, because the greater investment signals potential success in reducing the status gap.

The first and second findings relate to the effects of collaborative know-how (see Figure 6-9). Collaborative know-how reduces organizational reliance on previous

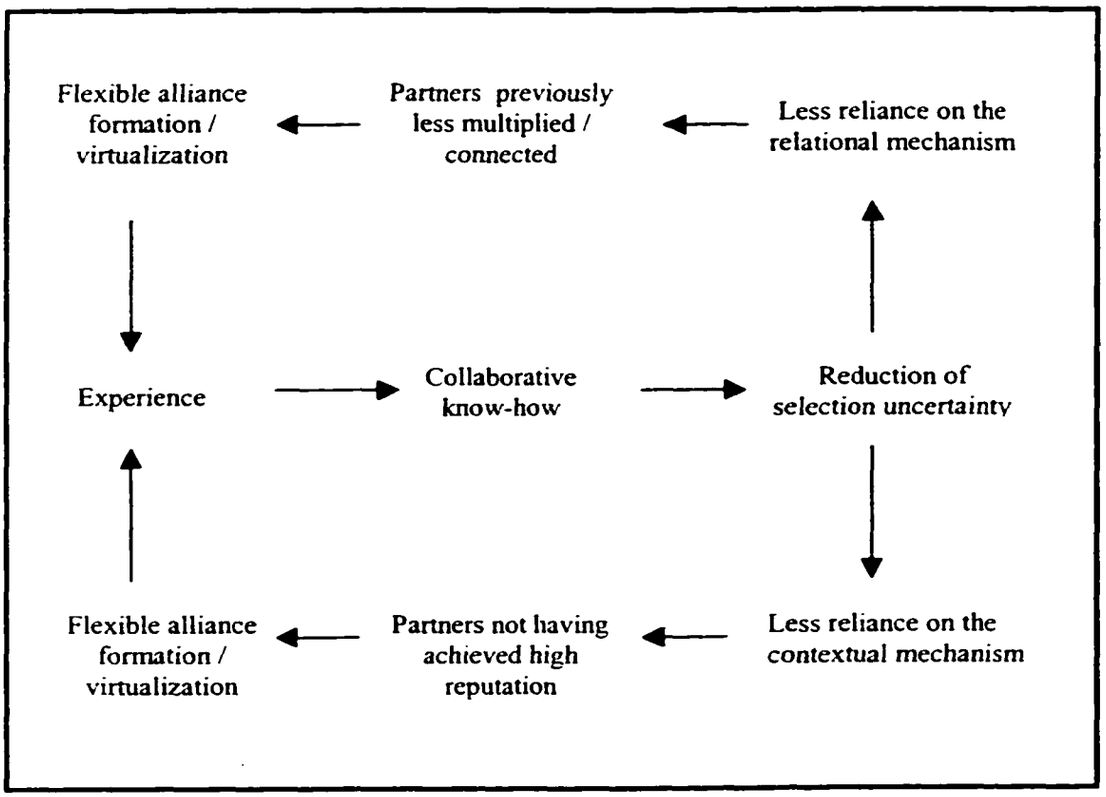

Figure 6-9: Summary of the Two Findings in Study 1

interactions and reputation in reducing selection uncertainty because more-experienced organizations should be better able to identify and select as alliance partners other organizations with non-redundant resources and cutting-edge technology. It has been reported that small-firm networks and alliances of entrepreneurial firms typically emerge out of social ties (Larson, 1992; Saxenian, 1994; Uzzi, 1996). This is probably because these firms have not accumulated enough collaborative know-how to reduce selection uncertainty, so interorganizational R&D networks become nested within previous interactions as a result of heavy reliance on the relational mechanisms in forming alliances. Collaborative know-how enables organizations to decouple and de-embed economic transactions from previous interactions and increase access to other organizations with which they have weak multiplexity.

In addition, organizations with more collaborative know-how are able to assess prospective partners without reliance on reputation, so they should have more access to cutting-edge technology at entrepreneurial firms. Therefore, this research provides some insights on why interorganizational networks of small and entrepreneurial firms are embedded in social networks and how organizations attenuate reliance on the relational mechanism in order to increase access to heterogeneous actors in organizational space. The evolution of interorganizational networks is interdependent with organizational learning and skills to identify and select alliance partners (Barkema et al., 1997; Doz & Hammel, 1998; Halebian & Finkelstein, 1999; Hill & Hellriegel, 1994; Lorenzoni & Lipparini, 1999; Powell, 1998; Powell et al., 1996; Simonin, 1997).

The first finding also presents an implication for the embeddedness literature. One of the emerging research agendas in this school is to view embeddedness as a variable and account for its variance. For instance, Uzzi (1996: 674-675) contends in his introductory section that "my aim is to advance the concept of embeddedness beyond the level of a programmatic statement by formulating a scheme that specifies how embeddedenss and network structure affect economic behavior" (see also Uzzi, 1999). With his data from supplier-manufactures relationships in the New York apparel economy and measures of organizational embeddedness by "summing the squared proportion of work done by a contractor for each of its manufacture" (686), he finds that a moderate level of organizational embeddedness, which enables organizations to combine advantages of both arms-length and embedded relations, enhances organizational survival most.

Block (1990: 54) also proposes another framework: that the 2 components of embeddedness encompass (1) "the degree to which behavior is price-driven" (marketness) and (2) "the degree to which self-interest places economic goals ahead of friendship, family ties, spiritual considerations, or morality" (instrumentalism). He uses these 2 analytical dimensions in examining the change of marketness and instrumentalism from 1850 to 1950 in the U.S. agricultural and manufacturing industries.

Moreover, given that duration of interorganizational relationships is another quantitative aspect of organizational embeddedness (Block, 1990: 51-54), the following works also relate to this emerging research agenda: (1) Baker's (1990) analysis of corporation-investment bank relationships, (2) Baker et al.'s (1998) analysis of advertising agency-client relationships, and (3) Levinthal and Fichman's

(1988) and (4) Seabright et al.'s (1992) analysis of corporation and accounting-auditor relationships.

Because the embeddedness school essentially proposes that economic behavior and motivation cannot be analyzed without reference to social networks and structures and that economic transactions originate from a history of social interactions that provide both constraints and opportunities to economic actors (Granovetter, 1985), it is reasonable to suppose that one of the analytical dimensions of organizational embeddedness is multiplexity that depicts closeness and sharedness between economic actors. If this research has shown anything of importance to the embeddedness literature, it is that organizational learning of collaborative know-how as one of the internal mechanisms changes the role of previous interactions in forming alliances and creating interorganizational networks. In other words, this research highlights a necessity for researchers to focus on complex interactions between intraorganizational and interorganizational behavior in examining the evolution and development of dynamism of interorganizational networks (Evans & Trist, 1965; Terreberry, 1968; Thompson, 1967).

In relation to the embeddedness school, the third finding confirms an instrumental aspect of previous interactions in executing business transactions in that ties facilitate contact in initiating alliance formation processes (Gulati, 1998; Larson, 1993). The instrumental value resides not in reduction of selection uncertainty, but in alleviation of the contact problem in initiating alliance formation processes. Entrepreneurial and small organizations with a lower reputation attempt to obtain endorsement from organizations with a higher reputation in order to enhance their survival rates (Stuart et al., 1999). However, because organizations with a higher

reputation receive contact from a number of other organizations in similar situations, it is not easy for the approaching entrepreneurial firms to attract the notice and attention of reputable organizations. The third finding suggests that ties may be able to alleviate this problem in creating interorganizational networks and that cultivation and development of social networks will be beneficial for them in obtaining a ticket to alliances with highly reputable organizations. Active participation in academic industrial conferences, as well as frequent visits to laboratories of other firms, may trigger creation of new ties that will result in alliance formation.

The third finding also points out an advantage of positive reputation in constructing interorganizational networks. Reputation enhances accessibility of heterogeneous resources and technology of other firms by decreasing the role of pre-existing or ongoing ties. Organizations with a higher reputation have more flexibility in selecting and contacting prospective partners in that a reputation enables them to approach complete strangers.

The fourth finding highlights an important and interesting aspect of reduction of selection uncertainty. I found a signaling effect of high technical intensity: alliance partners of higher technical intensity tend to be those with a higher reputation, and organizations with higher technical intensity are more likely to form a hierarchical governance form of alliance. Given that technical intensity indicates potentiality of technological innovation and organizational growth, organizations with higher technical intensity are more able to help prospective partners reduce selection uncertainty. This implies that although it is important for an approaching organization to reduce selection uncertainty concerning its prospective partners, it increases the likelihood of alliance formation if the prospective partners have little difficulty in

assessing the technology and reliability of the approaching organization. Alliance formation may require certain impression management, by which approaching organizations make a strong appeal to, and reduce selection uncertainty of, the prospective partners. This research uncovered that one of the approaches in managing impression necessary for alliance formation is to signal a strong orientation toward, and heavy investment in, R&D activities that attenuate prospective partners' selection uncertainty.

There is little doubt that virtual organizations are recognized as one of the emerging organization models. *Business Week*'s special report in 1993 provided a straight summary of this model:

> It (a virtual organization) is a temporary network of companies that come together quickly to exploit fast-changing opportunities. ... Because each partner brings its 'core competence' to the effort, it may be possible to create 'best-of-everything' organization. Every function and process could be world-class --- something that no single company could achieve. ... Partnerships will be less permanent, less formal, and more opportunistic. Companies will band together to meet a specific market opportunity and, more often than not, fall apart, once the need evaporates (*Business Week*, 1993; 98-102).

Virtual organizations form alliances with whomever they want in order to maximize complementarity and procure the best resources and technology from other organizations. Interorganizational networks are fluid and agile: on completion of a project, the formed networks are dissolved, and the organizations start seeking new best partners suitable for new projects. R&D alliances in the biotechnology industry certainly fit with this model in that the firms attempt to construct interorganizational networks so as to combine each other's strength and weakness.

Findings in this research, however, not only pose questions to the model but also propose some modifications. The necessity of reducing selection uncertainty, as well as the difficulty of making contact in initiating alliance formation processes, ever makes it almost impossible for any organizations to form alliances with whom they want. Organizations with less collaborative know-how need to rely on pre-existing and ongoing ties and reputation in reducing selection uncertainty, so the number and variety of prospective alliance partners cannot be infinite. In addition, it is hard for organizations with a lower reputation to approach reputable organizations and form alliances with them unless there exist certain ties between them. The virtual organization model is inaccurate in that it overlooks certain factors required for organizations to "virtualize."

Findings in this research suggest at least two important facilitators to virtualization of organizations. The first factor is active involvement in matchmaking opportunities such as scientific and business conferences and workshops. This involvement enables organizations to create new personal-level ties between scientists, managers, and BD professionals that increase the reachablility of reputable organizations. These opportunities are not only for scanning and identifying prospective partners but also for signaling organizations' presence to environment. The active involvement increases reachability to other, and specifically, reputable organizations and facilitates virtualization by cultivating personal-level ties.

The second factor is collaborative know-how. Organizations with a higher degree of collaborative know-how are able to form alliances without reliance on reputation and pre-existing or ongoing ties. This organizational learning of how to form and manage networks and the internal effort to reduce selection uncertainty

expand the number and variety of prospective partners. Although this research presumes, according to prior findings, that experience fosters collaborative know-how, just accumulating alliance and interorganizational experience may not directly lead to organizational learning of collaborative know-how. Organizations may be required to organize and systematize various experiences scattered through the history of organizations and identify certain patterns that make selection of alliance partners work. In addition, organizations are able to learn through grabbing and hiring knowledgeable personnel (Cyert & March, 1963), importing assessment methods for alliance partners from other successful organizations, and receiving advice from consulting firms and venture capitalists. Because these learning efforts decrease the role of ties and reputation in identifying and selecting alliance partners, organizations with a higher degree collaborative know-how should be more able to expand the range of prospective partners to include totally strangers and organizations with low reputation scores.

There are several limitations to Study 1, that provide suggestions for future research. First, although I obtained an indirect support for an argument that collaborative know-how reduces organizational reliance on the relational mechanism and enables organizations to form alliances with organizations with low multiplexity, I did not obtain any evidence that directly supports it. A further analysis is required to explore this causal association. One of the problems with the archival data set used here is that it presumes a close linkage between experience and learning and fails to capture processes in which organizations transform experience into organizational learning (Adler, 1994; Nonaka, 1992). Accumulation of experience does not necessarily guarantee development of collaborative know-how unless organizations

use the experience in developing routines for assessing prospective partners. Because two organizations with the same levels of alliance experience may not develop the same degree of collaborative know-how, future research should find a way to deal with this assumption about the close linkage between experience and learning.

Second, although a focus on R&D alliances in the biotechnology industry enables me to incorporate research contexts and results from the fieldwork in interpreting these quantitative findings, it is appropriate, as in any research, to expand the scope of research to include other industries, other types of alliances, and other geographical locations with longer observation windows. In doing so, it would be possible to focus on the population-level data and construct complete network data that would enable researchers to include not only organizational-level factors, but also structural and contextual factors into analytical schemes. An alternative approach, which must be interesting for those who study the organizational life-cycle model (Greiner, 1972; Quinn & Cameron, 1983), would be to focus on specific firms' alliance history and find historical patterns of alliance formation. Although, for instance, Meyer and Zucker (1989) find that organizations at different stages in the life cycle demonstrate different patterns of relationships with other organizations, the data are much more sparse. Collaborative know-how, organizational size, and other factors generate differences between entrepreneurial and mature organizations in terms of their motivation to form alliances, ways of reducing selection uncertainty, and the impact of alliances on their own competitive advantage (Gulati, 1998).

Third, Simonin (1997) finds that collaborative know-how increases the likelihood that organizations will manage and run alliances effectively. This research uncovered the fact that collaborative know-how enables organizations to form

alliances with those with weak multiplexity and a lower reputation. However, there may exist other effects that development of collaborative know-how brings about. For instance, Uzzi (1996, 1999) claims that a well-balanced portfolio of arms-length and embedded ties enables organizations to combine the strength of the two different types of ties and to outperform others with an unbalanced portfolio. While his studies explore consequences of the network portfolio (Gulati, 1998), still little is known about antecedents of it: why some organizations can construct the well-balanced portfolio while others cannot. It may be possible that organizations with a higher degree of collaborative know-how not only coordinate relationships with each of their partners, but also manage the entire network in which they are embedded.

Fourth, as noted above, this research implies a potential linkage between growth of organizations and evolution of their interorganizational networks. There must be a life-cycle model of interorganizational networks like that of organizations (Greiner, 1972; Quinn & Cameron, 1983). Although this research provides some insights into the linkage, it did not analyze alliances and the related behavior of failing organizations. For instance, Meyer and Zucker (1989) finds that low-performing organizations typically face conflicting interests and demands on their performance that enable organizations to stay alive regardless of their low performance. Their research implies that declining organizations may have a particular pattern of interorganizational relations and management of other organizations in the environment. In order to complete the model that accounts for the growth of organizations and evolution of their interorganizational networks, it is necessary for future research to examine with whom the failing organizations construct networks, as well as how failing organizations reduce selection uncertainty.

Finally, it must be noted that some of the statistical findings in Study 1 are not strong, but indirect. Extension of the findings was required to interpret them. This is probably because of the assumption about the linkages between organizational attribution and actual activation of the mechanisms: organizations use and activate the mechanisms whenever they have a chance to do so. Because this research used archival data, it did not examine exactly what mechanism organizations used in forming alliances or exactly how they reduced selection uncertainty prior to selection. It may even be true that organizations in the data set made no effort to reduce selection uncertainty in forming alliances. Having attributes is a necessary condition for being able to use them, but it is not sufficient: firms that have certain resources (e.g., collaborative know-how) may choose not to use them. For instance, even though two firms had a high degree of multiplexity at time *t-1* and formed an alliance at time *t*, the alliance may have emerged out of cold calls of BD professionals. For another instance, even though a partner had a higher reputation, a scientist in the focal firm had a collegial tie with one in the partner, which cannot be measured by archival data, so the focal firm did not necessarily activate the contextual mechanism but the relational mechanism. Therefore, substituting organizational attributions for usage and activation of the uncertainty reduction mechanisms may have caused the weak and indirect findings.

In this chapter I presented results of testing H1 – H4 on interrelatedness among the uncertainty reduction mechanisms in order to answer one of the second set of research questions: how they are interrelated and how organizations change their use of the relational mechanism. Two of the major findings are that (1) organizations with a higher degree of collaborative know-how are less likely to form alliances with other

organizations with higher degree of multiplexity and therefore rely upon the relational mechanism in reducing selection uncertainty and (2) organizations with a higher degree of collaborative know-how are less likely to form alliances with other organizations with a higher degree of reputation and therefore rely upon the contextual mechanism in reducing selection uncertainty.

CHAPTER 7: METHODS – STUDY 2

In this chapter I provide the methodology for Study 2, aimed at testing H5 – H6 on associations between the relational mechanism and alliance performance with mail-survey data. In Chapter 4 I hypothesized that use of the relational mechanism in forming alliances can either increase or decrease alliance performance. For one thing, the relational mechanism may restrict organizational access to heterogeneous and non-redundant resources and knowledge outside organizational boundaries. For another, it may enable allying organizations to transfer behavioral expectations and norms of reciprocity developed from prior interactions to ongoing alliances to decrease the likelihood of partners' malfeasance and opportunism.

7-1: Sample and Mail-Survey Procedures

The unit of analysis in Study 2 is an alliance. The sample frame included 285 publicly-traded biopharmaceutical firms identified in *Recombinant Capital Biotechnology Alliance Database* (ReCap), *Corporate Directory of Technology Companies*, *Windhover's Healthcare Strategists*, and *Standard & Poor's Compstat*. Both archival and survey data were collected and used in Study 2. For data on alliance performance and the relational mechanism, questionnaires were distributed in February 2000 to BD executives or CEOs of the 285 firms. To ensure the highest possible response rates, I sent follow-up cards to all non-responding firms 3 weeks after the initial distribution and resent the survey packets to a random selection of 90 of the non-responding firms 3 weeks after the second mailing[7]. As a result of these

[7] The cover sheet, the follow-up card, and the survey sheets are presented in Appendix 7-1, 7-2, and 7-3, respectively.

efforts, 23 firms provided information on 46 alliance cases (the company-level response rate = 8%).

Non-response biases were checked with the following 1998 Compustat data: (1) ROI (return on investment), (2) ROE (return on equity), (3) ROA (return on assets), (4) R&D expenditure, (5) net income, (6) asset size, and (7) year-end stock price. Running a logistic regression, I found that there was no significant difference between non- and responding firms in terms of these characteristics (see Appendix 7-4). However, a concern still remains about possible selection biases in this sampling scheme: alliances only of surviving firms were examined. Because previous research claims that alliance activities may be associated with organizational performance and, more importantly, organizational survival (Koh & Venkatraman, 1991; Mitchell & Singh, 1996; Oliver & Baum, 1991), firms that had disappeared and were excluded from the sampling may have had particular patterns of alliance formation and usage of the relational mechanism. Because of this exclusion, possible selection biases should not be overlooked in interpreting the following results.

Each survey packet contained three parts: (1) a cover letter, (2) a questionnaire on the firm's BD activities, and (3) 3 separate questionnaire sheets to collect information on 3 of the recent R&D alliances (see Appendix 7-1). First, I stated the purpose of this research, guaranteed confidentiality and anonymity, provided instructions for completing the survey sheets, and requested their participation in the study.

Second, I collected organizational-level data on general BD activities from BD executives. Third, with separate survey sheets, I also collected information on alliance formation processes and alliance performance from BD executives, other BD

professionals, or other relevant organizational members. I asked BD executives or CEOs to select 3 recently formed alliances and redistribute survey sheets to those who were most familiar with each of them. I expanded the scope of the respondents because it was found in the fieldwork that some BD executives are not necessarily most knowledgeable about historical details of each alliance formation process. I also limited my scope to R&D alliances from 1995 to 1999 in order to alleviate a recall problem (Marsden, 1990). A summary of all of the variables used in Study 2 is available in Table 7-1.

7-2: Dependent Variable - Alliance Performance

As noted above, alliance performance is defined as "the extent to which the involved parties perceive each other organization (agency in original) to carry out its commitments and judge the relationship to be worthwhile, productive and satisfying" (Van de Ven & Ferry, 1980: 327). I modified Van de Ven and Ferry's (1980) performance measures and constructed the following seven-Likert-scale items:

1. The partner firm carried out the commitments it initially agreed to in regard to my firm (*Commitment*).
2. I feel that the partnership was scientifically successful (*Scientific success*).
3. The time and effort spent in developing and maintaining the relationship with my partner were worthwhile (*Worthwhile effort*).
4. Overall, I am satisfied with the relationship between my firm and the partner (*Overall satisfaction*).

These 4 items are highly correlated with each other. The mean of the interitem correlations is .63, and the Cronbach's alpha is .88. I indeed extracted only a single factor in a factor analysis of these 4 items with maximum-likelihood estimations and

Table 7-1: Variables in Study 2

	Construct	*Variable Name*	*Data Source*
Dependent variable	**Alliance performance**	*Commitment* (7 point Likert-scale)	Mail survey
		Scientific success (7 point Likert-scale)	Mail survey
		Worthwhile effort (7 point Likert-scale)	Mail survey
		Overall satisfaction (7 point Likert-scale)	Mail survey
		Averaged alliance performance	Computed
		Categorical alliance performance (1: high; 0: low)	Computed (Median-split)
Independent variable	**Use of the relational mechanism**	*Tie strength* (average of 4 items of tie strength) and *Categorical tie strength* (1: high; 0: low)	Mail survey
		Alliance origin (categorical variable)	Mail survey
Moderator	**Collaborative know-how**	*R&D experience* (1: high; 0: low)	ReCap
		IOR experience (1: high; 0: low)	ReCap
		Alliance age (1: high; 0: low)	Prospectus or Biotechnology Directory
	Boundary spanning	*N of BD professionals* (1: high; 0: low)	Mail survey
	Technical intensity	*Technical intensity* = R&D expense (t-1) divided by asset (t-1) (1: high; 0: low)	Compustat
	Reputation	*Partner's reputation* = {(log (the number of academic publications from time t-2 to t) + 0.1) + (log (the number of patent from time t-2 to t))} / 2} (1: high; 0: low)	Science Citation Index and U.S. Patent and Trademark Office
	Characteristics of contact	*CEO-CEO contact* (1: yes; 0: no)	Mail survey
		BD-BD contact (1: yes; 0: no)	Mail survey
		CSO-CSO contact (1: yes; 0: no)	Mail survey
		Own contact (1: yes; 0: no)	Mail survey
	Characteristics of alliances	*Symmetrical collaboration* (1: yes; 0: no)	Mail survey
		Downstream alliance (1: downstream; 0: upstream)	Mail survey
	Financial Data	Asset at time t-1 (1: high; 0: Low)	Compustat
		(Calendar-year) stock price at time t-1 (1: high; 0: low)	Compustat
		Net income at time t-1 (1: high; 0: low)	Compustat

the varimax rotation (results are not shown). Therefore, I created a new variable named *averaged alliance performance* by taking means of the 4 items and used both unaggregated and aggregated performance data in the following analyses, depending on which statistical methods I employed.

While it may pose a problem that this research collected the perceptional performance data from only one side of allying firms (Whetten, 1980), it is also certain that managers' primary concern is to increase their own competitive advantage when they form alliances. At least they do not intentionally and purposefully form alliances that asymmetrically deliver benefits only to their partners. It is not desirable, but reasonable, to focus on how responding organizations view performance of their alliances and examine what accounts for differences in performance (Whetten, 1980).

7-3: Independent variables: The relational mechanism

Two independent variables in Study 2, as proxies for the relational mechanism, are (1) strength of ties between contact persons (*tie strength*) and (2) original contact points that initiated relations between contact persons (*alliance origin*). Contact persons are defined in the survey as "those who played the most influential role in initiating the partnership formation process."

Several measures of tie strength in previous research were used in constructing the *tie strength* measure for this study. Granovetter (1973) defined tie strength as "a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie." Among many empirical studies that provide measurements of tie strength, Marsden and Campbell (1984) and McPherson et al. (1992) are of great use in operationalizing tie strength for the purpose of this research.

Marsden and Campbell (1984) review various measurement approaches in previous research and examine which of the measurements is really valid and useful. The measures examined include:

1. Closeness (an acquaintance, good friend, and very close friend)
2. Time (frequency and duration of interaction)
3. Breadth of discussion topics (i.e. family, friend, politics, local events, work, and leisure)
4. Mutual confiding for election vote and personal issues
5. Labels of relationships (kinship, co-worker, and neighbor)
6. Membership in voluntary organizations (the number of organizations in which both ego and alter have memberships)
7. Social distance (occupational prestige and years of education).

They find that the most useful measure is "closeness," which is "free of contamination by other indicators and predictors" (Marsden & Campbell, 1984: 498). For instance, the use of frequency overestimates the tie strength between those who are neighbors or co-workers. Similarly, using duration overestimates the tie strength between relatives. All reviewed measures of tie strength are not consistently correlated with each other. In the sense that measures do not compound different aspects of tie strength, "closeness" is "on balance the best indicator of the concept of tie strength among those available to us" (Marsden & Cambell, 1984: 498). Therefore, following their suggestion, this research measured tie strength by asking respondents to indicate whether the contact person in the allying firm was a stranger (coded 1), an acquaintance (coded 2), a good friend (coded 3), or a very close friend (coded 4)[8].

[8] I did not present a definition of each item in the survey.

The additional measures of tie strength do not undermine the quality of this research but provide additional information and enrich our understanding of the role of the relational mechanism in R&D alliance formation. I used McPherson et al. (1992) to develop additional measures of tie strength. Two advantages of using their approach are that (1) consistent with Granovetter (1973) and Marsden and Campbell (1984), they took a multidimensional approach to tie strength and used 3 ways to measure it, and, (2) as will be argued below, their measurements are consistent with a recent theoretical development, particularly Burt's (1992) structural hole model.

First, one of their measures is frequency of interaction. The higher frequency of interaction indicates a greater amount of shared time, shared information, and a greater emotional bond. The higher frequency of interaction between people means stronger ties between them. Following Granovetter (1973), I asked the respondents how often the contact persons saw each other prior to the initial contact to discuss the possibility of alliance. I used the following coding scheme for this variable: (1) Never, (2) Once a year or less, (3) Once every 6 months, (4) Once every 3 months, (5) Once a month, (6) Once a week, and (7) More than once a week.

The second additional measure, relating to the previous one, is the length of relationship between contact persons prior to the initial contact to discuss the possibility of alliances. Their long relationships indicate a greater amount of shared time, shared information, and greater emotional attachment. I asked the respondents how long the contact persons knew each other prior to the initial contact to discuss the possibility of alliance. I used the following coding scheme for this variable: (1) Had never met, (2) Less than a month, (3) Less than a year, (4) 1 – 3 years, (5) 3 – 10 years, and (6) More than 10 years.

The third additional measure is presence of mutual friends. This is a substitution for density in McPherson et al. (1992) and partially consistent with Burt's (1994) argument on structural holes. A structural hole is "an opportunity to broker the flow of information between people and control the form of projects that bring people from opposite sides of the hole" (Burt, 1997: 340). A crucial implication of his argument for this research is that information redundancy is a result not only of direct connection (contagion) but also of structural equivalence and indirect connections by mutual contact. Even though actor X has weak ties to A, B, C, and D, information in X's network can be redundant when A, B, C, and D have very close relations and exchange information frequently.

Measurement of density or indirect connections requires collection of network data (Knoke & Kuklinski, 1982). Marsden (1990: 453) noted that density is usually measured by either "the mean strength of connections among units in a network" or "the proportion of links present relative to those possible." McPherson et al. (1992) also measures density by examining what proportion of the possible contacts among alters actually exists. Moreover, Burt (1992) takes a similar approach and measures indirect connections between ego X and alter A by the proportion of A's relations invested in contact with another alter B who has in turn invested in X. Although my non-network data did not allow me to measure density in the precise way prescribed in previous research, I was able to examine the presence of mutual information by asking the number of mutual friends prior to alliance formation. The higher scores of these indexes indicate stronger social ties, given that the more mutuality the network actors have, the denser a network and the stronger the social ties. Instead of directly asking how many mutual friends the contact persons had, I used a scaled measurement and

asked them to consider the names of five close business friends of the contact person in the focal firm. I then asked how many of them were also friends of the contact person in the allying firm. I used the following coding scheme for this variable: (1) none, (2) 1 person, (3) 2 persons, (4) 3 persons, (5) 4 persons, and (6) 5 persons.

In order to simplify the variable schemes, I standardized each item and obtained the Cronbach's alpha, a scale-reliability test. The average of interitem covariance was .46, and the alpha was .77. I created a new aggregated variable, *tie strength*, by taking the means of these items.

The second independent variable indicates places where contact persons originally initiated relationships: where and how 2 contact persons originally met. On the basis of the findings in the fieldwork as well as the pre-tests, I arrived at the following nine items, plus "other"[9], for this categorical variable (see also Granovetter, 1973):

1. They used to work in the same company.
2. They went to the same school or university.
3. One of them sat on the board of the other's firm.
4. Both are committee members of other firms or other organizations (e.g., industrial associations).
5. They met at a workshop or conference.
6. They met when one of them visited the other's firm during her/his business trip.
7. A venture capitalist introduced them.
8. Someone other than venture capitalists introduced them.
9. One of them found the other's name in a directory or database.

Because the first and second items indicate previous shared experience along with the academic and professional career, I recoded them as "shared experience." The third

[9] All of the 3 responses for "other" actually fitted with the original categories.

and fourth items represent shared memberships in other organizations, so I recoded them as "shared membership." The fifth and sixth items indicate that relationships started from scientific or professional activities, so I re-coded them as "scientific / professional activities." The seventh and eighth items represent third-party referrals, recoded as "third-party referrals." Finally, the last item is termed "cold call." Because the ordering

of these re-coded items in a numerical scale appears to be arbitrary, I created a categorical variable and termed it *alliance origin*.

Table 7-2 summarizes the frequencies of each of the 5 items. Although previous research taking the embeddedness approach emphasizes the importance of pre-existing and ongoing personal connections in forming alliances (i.e., Larson, 1993; Uzzi, 1996; 1999), this frequency table indicates that 67% of alliances are formed through cold calls, conference participation, and business trips that do not necessarily involve long-term relationships between contact persons. It is noteworthy here that there are varieties of original contact points and, more generally, of personal ties used in forming alliances.

7-4: Data-Analysis Strategy and Other Variables

A primary purpose of Study 2 is to examine effects of the relational mechanism on alliance performance. The relational mechanism is measured with a focus on relationships between contact persons. In examining this causal relationship, I selected some statistical methods that do not require or assume a large number of observations: (1) Mann-Whitney U tests (M-W U tests), (2) Hotelling's T-squared generalized means test (Hotelling test), and (3) Fisher's exact tests (Fisher's tests).

Table 7-2: Frequency Table of *Alliance Origin*

	Frequency	%
Shared experience	5	11.11
Shared membership	3	6.67
Third-party referrals	7	15.56
Scientific / professional activities	17	37.78
Cold call	13	28.89
Total	45	100

I first used M-W U tests for examining associations between *tie strength* and *averaged alliance performance* (Siegel, 1956). The M-W U test is one of the non-parametric tests for examining the independence of two variables. The independent sample t-test, which is more popular for most of us, is not appropriate here, because it presumes a large number of observations and normal distribution of dependent variables (Moore and McCabe, 1993). M-W U tests determine whether two sampled populations are equivalent in location and is "a most useful alternative to the parametric t-test when the researcher wishes to avoid the t-test's assumptions" (Siegel, 1956: 116). Because mean differences between two groups are examined in M-W U tests, I made a dummy indicator for *tie strength* with a median-split and used it as *categorical tie strength* (coding a high degree of tie strength as 1).

Second, in Hotelling's tests, I examined associations between the relational mechanism and a set of 4 un-aggregated performance variables (Hair et al., 1998; Rencher, 1995). This is one of the multivariate methods to examine whether or not a group indicator creates statistically significant mean differences of sets of dependent variables that are components of a single construct (Hair et al., 1988). I used *categorical tie strength* in this test and examined whether or not two different levels of *tie strength* change the means of sets of 4 alliance performance variables.

Third, in Fisher's tests, I assessed the independence between *categorical tie strength / alliance origin* and *categorical alliance performance*. *Categorical alliance performance* is a dummy indicator of *alliance performance* with a median-split (coding higher performance as 1). Fisher's tests are useful for examining the independence of two categorical variables and testing a null hypothesis that two variables are independent. A core idea of this test is similar to that of popular x^2 tests

of independence: "enumerate all possible outcomes consistent with a given set of marginal totals and add up the probabilities of those tables more extreme than the one observer" (Le, 1998). However, because an assumption of x^2 tests requires us to obtain a large number of observations, Fisher's tests are more appropriate in this research (Agresti, 1996: 39).

Finally, while the analyses so far have exclusively focused upon simple associations between the relational mechanism and alliance performance, there may exist factors that moderate this causal association as found in previous research, as well as in Chapter 6 above on interrelatedness among the different uncertainty reduction mechanisms. I therefore collected supplementary data and added them as moderators to Fisher's tests. Variables I used include (1) *R&D experience*, (2) *IOR* (interorganizational relations) *experience*, (3) *alliance age*, (4) *the number of BD professionals*, (5) *technical intensity*, (6) *the relative reputation index*, (7) *CEO-CEO contact*, (8) *BD-BD contact*, (9) *CSO-CSO contact*, (10) *own contact*, (11) *symmetrical collaboration*, (12) *upstream alliance*, (13) *assets*, (14) *stock price*, and (15) *net income*. To be included in Fisher's test as moderators, these data were originally collected as, or transformed into, dummy indicators.

(1) *R&D experience*, (2) *IOR experience*, and (3) *alliance age*: following previous research (i.e., Barkema et al., 1997; Powell et al., 1996; Simonin, 1997), I used these experience data as a proxy to collaborative know-how, a component of the internal mechanisms. *R&D experience* and *IOR experience* are the count data that contain the number of R&D alliances and IOR deals that the responding firms had made by the time of alliance formation. The IOR deals encompass licensing, supplying, manufacturing, asset purchases, and marketing agreements, as well as R&D

alliances. *Alliance age* is the organizational age of responding firms at the point of alliance formation and indicates levels of organizational general experience in managing relations with other organizations (e.g., government agencies, universities, professional organizations, industrial associations, financial institutions, and consulting firms) (Powell et al., 1996). I obtained these data from ReCap, prospectuses, and the *Biotechnology Directory* and recoded them into a dummy indicator with a median-split (coding higher collaborative know-how as 1).

(4) *N of BD professionals*: I used this information to measure levels of business development activities as boundary-spanners. There are various ways of measuring levels of boundary-spanning activities. For instance, one of the indicators used in Keller and Holland (1975) is the total number of magazines, journals, and newspapers that their survey respondents regularly read to scan the environment. For another instance, Friedman and Podolny (1992) use formal organizational structures in identifying boundary-spanners (i.e. an union bargaining team and a management bargaining team). In this research, I used the number of BD professionals to measure the degree of boundary-spanning activities for the following two reasons. For one thing, I found in my fieldwork that BD professionals are boundary-spanners in organizations who scan the environment, identify prospective alliance partners, collect information about them, make contact, and initiate and facilitate due-diligence processes. For another, levels of formal employment of BD professionals correlate with, and indicate, organizational information processing capabilities in scanning environment and disseminating relevant information to decision makers (Galbraith, 1973; Thompson, 1967). In constructing this variable, I simply asked survey respondents the number of BD professionals at the point of alliance formation and

recoded the data into a dummy indicator with a median-split (coding the higher number as 1).

(5) *Technical intensity*: As noted above, technical intensity is typically measured as the proportion of expenditures on R&D activities to annual sales (Milkovich et al., 1991). However, this traditional measure is not appropriate for biotechnology firms, because many of the biotechnology firms do not make any profit. Indeed, the average of the 1998 net income of 297 publicly-held biotechnology firms is – $4.19 billion. I constructed *technical intensity* at time t by dividing R&D expenditure at time *t-1* by asset, instead of sales, at time *t-1* so as to examine effects of the extent of R&D investment relative to firms' size and substantial performance. I collected the data from Standard & Poors' Compustat and recoded them into a dummy indicator with a median-split (coding higher *technical intensity* as 1).

(6) *Partner's reputation*: In operationalizing the contextual mechanism, I collected partners' publication and patent data. In the biotechnology industry, where scientific research and knowledge creation are highly valued, scientific contribution and intellectual property are crucial for organizational growth and survival (Barry et al., 1992; Ryan et al., 1995). First, I used the Science Citation Index Database and collected the number of academic publications by partners from time *t-2* to *t*. I then used the U.S. Patent and Trademark Office Database and collected the number of commercial patents by partners from *t-2* to *t*. While it is more desirable to incorporate the number of times papers or patents are cited in assessing impacts of the works on the industry and reputation of firms (Latour, 1987; Stuart, 1998), that is difficult to do because in the biotechnology industry each firm with unique technology tends to

specialize in a variety of therapeutic fields and create scientific and commercial outputs for different sizes of markets.

The log-transformed publication and patent data are highly correlated and related with each other: (1) r = .77 and (2) Cronbatch's alpha = .84. *Partner's reputation* is a dummy indicator based on means of these two data with a median-split (coding the higher score as 1).

(7) *CEO-CEO contact*, (8) *BD-BD contact*, (9) *CSO-CSO contact*, and (10) *own contact*: these 4 variables indicate characteristics of first contacts that lead to discussions of possibilities of alliance formation. While the first 3 describe contact persons' positions and roles at each of the allying firms, the last variable indicates an initiative taken by one of the allying firms in starting discussions. When contact persons were both CEOs in the responding and the allying firms, I coded *CEO-CEO contact* as 1. Similarly, when the contact persons were both BD professionals or CSOs (chief scientific officers), I coded *BD-BD* and *CSO-CSO contact* as 1, respectively. Finally, *own contact* was coded as 1 when it was responding firms that made first contact. For the first set of the three variables, I asked respondents to identify positions of contact persons in both the responding and the allying firms and recoded the data. For *own contact*, I asked the subjects whether or not they made first contact to start the discussions.

(11) *Symmetrical collaboration* and (12) *downstream alliance*: these variables are moderators that depict two important characteristics of alliances. *Symmetrical collaboration* indicates whether or not allying firms give equal effort to collaborate in alliances. Following Gulati and Singh (1998) with some modifications, I asked the respondents to identify the structure of their alliances by one of the following 4 items:

(1) joint venture (partners create a separate entity in which each owns a portion of the equity), (2) minority investment (one partner takes a minority equity position in the other), (3) collaborative alliance (partners work equally without creating a new organizational entity and sharing or exchanging equity), and (4) contractual alliance (one of the firms outsources its research projects to the other with some payments)[10]. I recoded "joint venture" and "collaborative alliance" into "symmetrical alliances" (coded as 1) and "minority investment" and "contractual alliance" into "asymmetrical alliances" (coded as 0). While the former two structures are typically designed to facilitate equal and symmetric collaboration between allying firms, firms employ the latter two structures when resources, technology, and skills flow asymmetrically from one to the other with some payment or equity investment (Windhover, 1997).

Downstream alliance indicates whether or not alliances initially involved projects or products at stages in drug-discovery processes close to final commercialization. The subjects were asked to indicate the project / product stages at the point of alliance formation according to the following categories: (1) synthesis and extraction, (2) biological screening and pharmacological testing, (3) pre-clinical studies (toxiology and safety testing and pharmaceutical dosage formulation and stability), (4) clinical studies phase I, (5) clinical studies phase II, and (6) clinical studies phase III. Because projects after screening and pharmaceutical testing are usually considered to be downstream (Pharmaceutical Research and Manufacturers of America, 2000; Standard & Poors', 1999), I recoded the data as 1 when projects or products were upstream.

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[10] I provided a definition of each structure in the actual survey.

(13) *Asset*, (14) *stock price*, and (15) *net income*. I also examined moderating effects of 3 financial indicators obtained from Standard & Poors' Compustat on relationships between *tie strength / alliance origin* and *alliance performance*. The first financial indicator is the asset size of firms at time *t-1*. Asset means any possession that has value in an exchange and is a proxy for organizational size. The second indicator is the calendar-year-end stock price of firms at time *t-1*. This is considered to indicate not only shareholder wealth but also the value of firms assessed by investors in financial stock markets (Abowd, Milkovich, & Hannon, 1990; Gerhart & Milkovich, 1990). In the biotechnology industry where specialized investors knowledgeable about biotechnology and drug-discovery processes play a crucial role in determining firm value, stock price is one of the indicators that represent firms' current financial values delivered to shareholders and potential growth in future. The third indicator is net income at time *t-1*. Net income is the firm's total earnings, reflecting revenues adjusted for costs of doing business, depreciation, interest, taxes, and other expenses. Although this is viewed as one of the indicators of firm performance in other industries, it must be noted that have net income typically describes costs for running a business in the biotechnology industry, where most of the firms that do not have commercial products are in the red.

CHAPTER EIGHT: RESULTS – STUDY 2

In this chapter I provide results of statistical analyses for Study 2 aimed at testing H5 – H6 on associations between the relational mechanism and alliance performance with mail-survey data. I first tested their direct and simple associations with non-parametric tests for mean difference (Mann-Whitney U test), Hotelling's T-squared generalized means tests, and Fisher's exact tests. I then tested effects of factors that moderate associations between the relational mechanism and alliance performance with Fisher's exact tests. I also provide interpretations of findings, limitations of Study 2, and directions for future research. Two of the major findings in this statistical analysis are that (1) there exists no direct and obvious association between the relational mechanism and alliance performance and (2) such associations emerge when we introduce moderators into the analytical schemes, including collaborative know-how, characteristics of contact persons, and firms' financial conditions. These findings imply that the role of pre-existing personal rapport in determining alliance performance is not simple, but contingent on ways in which organizations use pre-existing personal rapport in running alliances.

8-1: Results of Analyses

Table 8-1 presents means, standard deviations, and bivariate correlations for all variables, except for *alliance origin*, used in the following analyses. As noted above, the table indicates relatively high correlations among four different performance variables (*commitment*, *scientific success*, *worthwhile effort*, and *overall satisfaction*). It is, however, noteworthy that *Scientific success* does not always correlate with others (i.e., r (*scientific success*, *worthwhile effort*) = .37 and r *(scientific success*, *overall satisfaction*) = .56). The "mystery" of scientific research must decouple

Table 8-1: Descriptive Statistics , Correlations, and Frequencies of the Variables in Study 2

	Variable	N	Mean	S.D.	Min.	Max.	1	2	3	4
1	*Commitment*	45	5.24	1.52	2	7	1			
2	*Scientific success*	45	5.44	1.52	1	7	0.54	1		
3	*Worthwhile effort*	45	5.67	1.43	1	7	0.69	0.37	1	
4	*Overall satisfaction*	45	5.22	1.73	1	7	0.76	0.56	0.89	1
5	*Averaged alliance performance*	45	5.39	1.33	1.75	7	0.87	0.72	0.86	0.94
6	*Categorical alliance performance*	46	0.48	0.51	0	1	0.76	0.60	0.62	0.73
7	*Tie strength*	44	-0.08	3.06	-3.07	5.82	-0.03	-0 04	0.22	0.15
8	*Categorical tie strength*	46	0.52	0.51	0	1	-0.05	0.00	0.13	0.05
9	*R&D experience*	46	0.50	0.51	0	1	-0.14	-0.27	0.00	-0.05
10	*IOR experience*	46	0.54	0.50	0	1	-0.24	-0.36	-0.14	-0.20
11	*Alliance age*	46	0.52	0.51	0	1	0.20	0.06	0.32	0.37
12	*N of BD professionals*	46	0.54	0.50	0	1	-0.05	-0.26	-0.25	-0.32
13	*Technical intensity*	46	0.52	0.51	0	1	0.05	0.21	-0.22	-0.11
14	*Partner's reputation*	46	0.50	0.51	0	1	-0.07	-0.11	-0.01	-0.02
15	*CEO-CEO contact*	46	0.11	0.31	0	1	0.11	0.12	0.19	0.20
16	*BD-BD contact*	46	0.33	0.47	0	1	-0.03	-0.32	-0.19	-0.22
17	*CSO-CSO contact*	46	0.11	0.31	0	1	-0.24	-0.10	-0.36	-0.29
18	*Own contact*	46	0.67	0.47	0	1	-0.20	-0.14	0.03	0.04
19	*Symmetrical collaboration*	46	0.57	0.50	0	1	0.11	0.17	0.24	0.28
20	*Downstream alliance*	46	0.35	0.48	0	1	-0.01	-0.05	0.23	0.09
21	*Asset*	46	0.52	0.51	0	1	-0.03	-0.27	-0.27	-0.33
22	*Stock price*	46	0.50	0.51	0	1	-0.11	-0.26	-0.21	-0.30
23	*Net income*	46	0.50	0.51	0	1	-0.01	0.29	0.08	0.14

	5	6	7	8	9	10	11	12	13	14	15	16
5	1											
6	0.80	1										
7	0.09	0.18	1									
8	0.04	0.18	0.86	1								
9	-0.13	-0.18	-0.18	-0.09	1							
10	-0.27	-0.27	-0.28	-0.27	0.64	1						
11	0.28	0.09	-0.09	-0.09	0.09	0.00	1					
12	-0.26	-0.13	-0.10	-0.05	0.05	0.13	0.05	1				
13	-0.02	0.18	-0.19	-0.09	-0.18	-0.18	-0.09	0.23	1			
14	-0.06	0.04	-0.01	-0.14	0.05	0.05	0.05	0.00	0.14	1		
15	0.19	0.19	0.13	0.16	-0.32	-0.19	0.00	-0.17	0.16	-0.14	1	
16	-0.22	-0.18	-0.30	-0.24	0.05	0.27	0.05	0.40	0.05	-0.21	-0.23	1
17	-0.29	-0.33	0.27	0.21	-0.21	-0.25	-0.07	-0.09	-0.07	0.09	-0.11	-0.26
18	-0.07	-0.16	0.25	0.10	-0.10	0.06	0.10	0.03	0.00	0.07	0.05	0.18
19	0.24	0.20	0.11	0.18	0.09	-0.02	0.09	-0.05	0.18	-0.13	0.26	0.01
20	0.07	0.16	0.17	0.19	0.00	-0.07	-0.28	-0.13	-0.19	-0.06	0.25	-0.05
21	-0.26	-0.18	0.10	0.18	0.09	-0.01	-0.09	0.50	0.09	-0.04	-0.19	0.27
22	-0.26	-0.13	0.09	0.14	-0.05	-0.14	-0.14	0.27	0.05	0.09	-0.01	0.02
23	0.15	-0.05	0.13	0.14	-0.23	-0.41	-0.14	-0.36	-0.05	-0.09	0.33	-0.59

Table 8-1 (Continued)

	17	18	19	20	21	22	23
17	1						
18	0.09	1					
19	-0.14	0.23	1				
20	-0.12	0.01	0.15	1			
21	0.33	0.16	0.08	-0.07	1		
22	0.20	0.03	-0.05	0.15	0.50	1	
23	0.23	-0.23	-0.04	0.03	-0.22	-0.09	1

the scientific value of alliances from the quality of relationships between allying firms.

Table 8-2 shows results of M-W U tests in which I tested mean differences of 4 un-aggregated variables and an aggregated variable between the two groups: (1) alliances based on a lower degree of tie strength and (2) those based on a higher degree of tie strength. The table reports that there is no significant difference between these two groups in terms of alliance performance (i.e., p for *averaged alliance performance* = .523). Levels of alliance performance do not change, according to whether or not organizations build interorganizational networks and form alliances upon pre-existing strong personal rapport between contact persons. There is no association between alliance performance and the relational mechanism.

This finding is also replicated in Table 8-3, in which I conducted Hotelling's tests and examined whether or not 2 different levels of *tie strength* change the means of a set of the 4 performance variables. The results showed no statistical difference between the 2 groups (p = .655). Therefore, it is concluded that strength of ties between contact persons has neither a positive nor negative relationship to alliance performance.

There is also other evidence in Table 8-4, in which I conducted Fisher's tests of independence for *categorical tie strength*, *alliance origin*, and *categorical alliance performance*. While the table above shows results of Fisher's test between *categorical alliance performance* and *categorical tie strength*, the table below presents those between *categorical alliance performance* and *alliance origin*, a categorical variable. If alliances emerging from strongly tied contact persons outperformed those from weakly tied contact persons, the upper left and lower right cells would

Table 8-2: Results of Mann-Whitney U (M-W U) Tests -
Tie Strength* and *Averaged Alliance Performance

Performance Variables	Mean (Low Tie Strength)	Mean (High Tie Strength)	M-W U	Z-score	P-value
Commitment	5.2727	5.2174	244.500	-.198	.843
Sci. success	5.4090	5.4783	234.500	-.434	.664
Worthwhile effort	5.4545	5.8696	186.000	-1.585	.113
Overall satisfaction	5.0909	5.3478	217.500	-.825	.409
Averaged alliance performance	5.3068	5.4783	225.000	-.639	.523

Table 8-3: Results of Hotelling's T-squared Generalized Means Tests - *Categorical Tie Strength* and Four Measures of *Alliance Performance*

		N	Mean	S.D.	Min	Max
Low Tie Strength	*Commitment*	22	5.28	1.58	2	7
	Scientific success	22	5.41	1.37	3	7
	Worthwhile effort	22	5.45	1.26	3	7
	Overall satisfaction	22	5.09	1.60	2	7
High Tie Strength	*Commitment*	23	5.22	1.51	2	7
	Scientific success	23	5.48	1.68	1	7
	Worthwhile effort	23	5.87	1.58	1	7
	Overall satisfaction	23	5.34	1.87	1	7
	T^2	2.6418				
	F	.6144				
	P-value	.6548				

Table 8-4: Results of Fisher's Exact Tests –
Categorical Tie Strength*, *Alliance Origin*, and *Categorical Alliance Performance

		Categorical Alliance Performance		
		Low	High	
Categorical Tie Strength	Low	14	8	24
	High	10	14	22
		24	22	46

Pearson x^2 = .0027 (P-value = .958)
P-value of Fisher's exact = .155

		Categorical Alliance Performance		
		Low	High	
Alliance Origin	Shared experience	2	3	5
	Shared membership	1	2	3
	Third party referrals	6	1	7
	Sci. / prof. activities	7	10	17
	Cold call	8	5	13
		24	21	45

Pearson x^2 = 5.1494 (P-value = .272)
P-value of Fisher's exact = .268

show higher frequency than do the upper right and lower left cells. If places or points where two contact persons originally met determined levels of alliance performance, certain patterns would be observed in the table below. However, these two tests did not reject a null hypothesis that *alliance performance* is independent of *dummy tie strength* and *alliance origin* ($p = .155$ and $p = .268$, respectively). Degrees of strength of ties between contact persons and their original contact points are not associated with the level of alliance performance.

Results of these 3 tests provide a robust finding: the relational mechanism neither positively nor negatively influences alliance performance. No mater how strongly or weakly contact persons are tied prior to alliance formation, alliance performance does not change. No matter how relationships between contact persons originally started, alliance performance does not change.

However, the analyses so far have presumed the existence of obvious and definite associations between alliance performance and the relational mechanism and, hence, overlooked certain factors in building the model that moderates the associations. There are 3 reasons for this speculation. First, as shown in Table 8-1, *tie strength* or *dummy tie strength*, as well as *alliance performance*, is somehow correlated with many of the other variables. Although absolute values of the correlation coefficients do not seem to be high, it is more desirable in a statistical sense to control or remove effects of other variables from those of *tie strength* and *alliance origin* on *alliance performance*.

Second, previous studies report that alliance performance is a result of complex interactions of numerous factors and, hence, should not be viewed as a simple outcome of the relational mechanism. For one thing, previous research

indicates that the degree of uncertainty may moderate associations between the relational mechanism and selection uncertainty: when organizations expect a higher degree of environmental uncertainty, alliances based on personal rapport may be more able to achieve higher performance (Levinthal & Fichman, 1988; Seabright et al., 1992; Podolny, 1995). This is because personal rapport may help partnering organizations respond flexibly to emerging contingencies and resolve problems as quickly as possible. Types and contents of alliances, which partially determine future contingencies, may moderate associations between the relational mechanism and alliance performance.

For another, previous research implies that first contacts that initiate discussions of possibilities of alliance formation are associated with organizational capabilities to resolve problems encountered in alliances (Arino & Torre, 1998; Dyer & Singh, 1997; Ring & Van de Ven, 1993). Managers who mainly contribute to alliance formation tend to feel responsibility for the performance of the alliances. When these managers are structurally involved in problem-solving procedures in alliances, they may be more able and more willing to resolve encountered problems. Hence, how contact persons initiated alliance formation processes may matter in how the relational mechanism influences alliance performance.

Furthermore, on the basis of a finding in Study 1 that there exists interrelatedness among the 3 mechanisms for reducing selection uncertainty, it is reasonable to suppose that the internal and contextual mechanisms, which are related to the relational mechanism have certain influence over the causal associations between the relational mechanism and alliance performance.

Finally, it is also found in previous research that financial conditions of firms affect various aspects of interorganizational relations and are often crucial in determining performance of alliances. For instance, Barkema et al. (1997) find that international alliances of firms with a higher return on equity are less likely to be terminated, which is another measure of alliance performance (Gulati, 1998). For another instance, one of the regression models in Stuart (1998) demonstrates that biotechnology firms with higher sales are more likely to form alliances and engage in interorganizational collaborative projects. On the basis of these findings, it is reasonable to expect that financial conditions of firms may moderate relationships among ways in which organizations use social ties in forming alliances and alliance performance. For these reasons, it must be appropriate before reaching a conclusion to examine the presence and role of moderators in discussing effects of the relational mechanism on alliance performance.

Tables 8-5 to 8-19 provide results of Fisher's exact tests for associations between *categorical tie strength / alliance origin* and *categorical alliance performance* with 15 different moderators representing the alternative uncertainty reduction mechanisms and characteristics of contacts and alliances. The moderators include (1) *R&D experience*, (2) *IOR experience*, (3) *alliance age*, (4) *the number of BD professionals*, (5) *technical intensity*, (6) *the relativ- reputation index*, (7) *CEO-CEO contact*, (8) *BD-BD contact*, (9) *CSO-CSO contact*, (10) *own contact*, (11) *symmetrical collaboration*, (12) *downstream alliance*, (13) *assets*, (14) *stock price*, and (15) *net income*. The upper part of each table presents results of the tests for

Table 8-5: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *R&D Experience* as a Moderator

			Categorical Alliance Performance		
			Low	High	
Low R&D Experience	*Categorical Tie Strength*	Low	5	5	10
		High	5	8	13
			10	13	23
	Pearson x^2 = .3062 (P-value = .580)				
	P-value of Fisher's exact = .685				
			Low	High	
High R&D Experience	*Categorical Tie Strength*	Low	9	3	12
		High	5	6	11
			14	9	23
	Pearson x^2 = 2.1034 (P-value = .147)				
	P-value of Fisher's exact = .214				

			Categorical Alliance Performance		
			Low	High	
Low R&D Experience	*Alliance Origin*	Shared experience	2	1	3
		Shared membership	0	1	1
		Third-party referrals	2	1	3
		Sci. / prof. activities	3	5	8
		Cold call	3	5	8
			10	13	23
	Pearson x^2 = 2.3147 (P-value = .678)				
	P-value of Fisher's exact = .776				
			Low	High	
High R&D Experience	*Alliance Origin*	Shared experience	0	2	2
		Shared membership	1	1	2
		Third-party referrals	4	0	4
		Sci. / prof. activities	4	5	9
		Cold call	5	0	5
	Pearson x^2 = 10.2361 (P-value = .037)				
	P-value of Fisher's exact = .019				

Table 8-6: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *IOR Experience* as a Moderator

			Categorical Alliance Performance		
			Low	High	
Low IOR Experience	*Categorical Tie Strength*	Low	2	5	7
		High	6	8	14
			8	13	21
	Pearson x^2 = .4038 (P-value = .525)				
	P-value of Fisher's exact = .656				
			Low	High	
High IOR Experience	*Categorical Tie Strength*	Low	12	3	15
		High	4	6	10
			16	9	25
	Pearson x^2 = 4.1667 (P-value = 0.041)				
	P-value of Fisher's exact = .087				

			Categorical Alliance Performance		
			Low	High	
Low IOR Experience	*Alliance Origin*	Shared experience	2	1	3
		Shared membership	0	1	0
		Third-party referrals	2	1	3
		Sci. / prof. activities	2	6	8
		Cold call	2	4	6
			8	13	21
	Pearson x^2 = 3.3317 (P-value = .504)				
	P-value of Fisher's exact = .677				
			Low	High	
High IOR Experience	*Alliance Origin*	Shared experience	0	2	2
		Shared membership	1	1	2
		Third-party referrals	4	0	4
		Sci. / prof. activities	5	4	9
		Cold call	6	1	7
			16	8	24
	Pearson x^2 = 7.8929 (P-value = .096)				
	P-value of Fisher's exact = .085				

Table 8-7: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *Alliance Age* as a Moderator

			Categorical Alliance Performance		
			Low	High	
Low Alliance Age	*Categorical Tie Strength*	Low	7	3	10
		High	6	6	12
			13	9	22
	Pearson x^2 = .9026 (P-value = .342)				
	P-value of Fisher's exact = .305				
			Low	High	
High Alliance Age	*Categorical Tie Strength*	Low	7	5	12
		High	4	8	12
			11	13	24
	Pearson x^2 = 1.5105 (P-value = .219)				
	P-value of Fisher's exact = .414				

			Categorical Alliance Performance		
			Low	High	
Low Alliance Age	*Alliance Origin*	Shared experience	1	1	2
		Shared membership	1	1	2
		Third-party referrals	2	0	2
		Sci. / prof. activities	5	5	10
		Cold call	4	2	6
			13	9	22
	Pearson x^2 = 2.0057 (P-value = .735)				
	P-value of Fisher's exact = .809				
			Low	High	
High Alliance Age	*Alliance Origin*	Shared experience	1	2	3
		Shared membership	0	1	1
		Third-party referrals	4	1	5
		Sci. / prof. activities	2	5	7
		Cold call	4	3	7
			11	12	23
	Pearson x^2 = 4.5270 (P-value = .339)				
	P-value of Fisher's exact = .393				

Table 8-8: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *N of BD Professionals* as a Moderator

			Categorical Alliance Performance		
			Low	High	
Low N of BD Professional	*Categorical Tie Strength*	Low	6	4	10
		High	4	7	11
			10	11	21
	Pearson x^2 = 1.1732 (P-value = .279)				
	P-value of Fisher's exact = .395				
			Low	High	
High N of BD Professional	*Categorical Tie Strength*	Low	8	4	12
		High	6	7	13
			14	11	25
	Pearson x^2 = 1.0656 (P-value = .302)				
	P-value of Fisher's exact = .265				

			Categorical Alliance Performance		
			Low	High	
Low N of BD Professional	*Alliance Origin*	Shared experience	0	2	2
		Shared membership	1	2	3
		Third-party referrals	4	0	4
		Sci. / prof. activities	3	3	6
		Cold call	2	4	6
			10	11	21
	Pearson x^2 = 6.9682 (P-value = .138)				
	P-value of Fisher's exact = .148				
			Low	High	
High N of BD Professional	*Alliance Origin*	Shared experience	2	1	3
		Shared membership	0	0	0
		Third-party referrals	2	1	3
		Sci. / prof. activities	4	7	11
		Cold call	6	1	7
			14	10	24
	Pearson x^2 = 4.5150 (P-value = .211)				
	P-value of Fisher's exact = .184				

Table 8-9: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *Technical Intensity* as a Moderator

			Categorical Alliance Performance		
			Low	High	
Low Technical Intensity	*Categorical Tie Strength*	Low	8	2	10
		High	6	6	12
			14	8	22
	Pearson x^2 = 2.1214 (P-value = .145)				
	P-value of Fisher's exact = .156				
			Low	High	
High Technical Intensity	*Categorical Tie Strength*	Low	6	6	12
		High	4	8	12
			10	14	24
	Pearson x^2 = .6857 (P-value = .408)				
	P-value of Fisher's exact = .680				

			Categorical Alliance Performance		
			Low	High	
Low Technical Intensity	*Alliance Origin*	Shared experience	1	2	3
		Shared membership	1	2	3
		Third-party referrals	3	0	3
		Sci. / prof. activities	3	3	6
		Cold call	6	1	7
			14	8	22
	Pearson x^2 = 6.0519 (P-value = .195)				
	P-value of Fisher's exact = .228				
			Low	High	
High Technical Intensity	*Alliance Origin*	Shared experience	1	1	2
		Shared membership	0	0	0
		Third-party referrals	3	1	4
		Sci. / prof. activities	4	7	11
		Cold call	2	4	6
			10	13	23
	Pearson x^2 = 2.1298 (P-value = .546)				
	P-value of Fisher's exact = .660				

Table 8-10: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *Partner's Reputation* as a Moderator

			Categorical Alliance Performance		
			Low	High	
Low Partner's Reputation	*Categorical Tie Strength*	Low	8	2	10
		High	5	8	13
			13	10	23
	Pearson x^2 = 3.9685 (P-value = .046)				
	P-value of Fisher's exact = .090				
			Low	High	
High Partner's Reputation	*Categorical Tie Strength*	Low	6	6	12
		High	5	6	11
			11	12	23
	Pearson x^2 = .0475 (P-value = .827)				
	P-value of Fisher's exact = 1.000				

			Categorical Alliance Performance		
			Low	High	
Low Partner's Reputation	*Alliance Origin*	Shared experience	0	2	2
		Shared membership	0	1	1
		Third-party referrals	3	0	3
		Sci. / prof. activities	4	5	9
		Cold call	6	2	8
			13	10	23
	Pearson x^2 = 7.8534 (P-value = .097)				
	P-value of Fisher's exact = .086				
			Low	High	
High Partner's Reputation	*Alliance Origin*	Shared experience	2	1	3
		Shared membership	1	1	2
		Third-party referrals	3	1	4
		Sci. / prof. activities	3	5	8
		Cold call	2	3	5
			11	11	22
	Pearson x^2 = 2.033 (P-value = .730)				
	P-value of Fisher's exact = .824				

Table 8-11: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *CEO-CEO Contact* as a Moderator

			Categorical Alliance Performance		
			Low	High	
No CEO-CEO Contact	*Categorical Tie Strength*	Low	14	7	21
		High	9	11	20
			23	18	41
	Pearson x^2 = 1.9526 (P-value = .162)				
	P-value of Fisher's exact = .215				
			Low	High	
CEO-CEO Contact	*Categorical Tie Strength*	Low	0	1	1
		High	1	3	4
			1	4	5
	Pearson x^2 = .3125 (P-value = .576)				
	P-value of Fisher's exact = .800				

			Categorical Alliance Performance		
			Low	High	
No CEO-CEO Contact	*Alliance Origin*	Shared experience	2	3	5
		Shared membership	1	2	3
		Third-party referrals	5	0	5
		Sci. / prof. activities	7	9	16
		Cold call	8	3	11
			23	17	40
	Pearson x^2 = 7.3208 (P-value = .120)				
	P-value of Fisher's exact = .114				
			Low	High	
CEO-CEO Contact	*Alliance Origin*	Shared experience	0	0	0
		Shared membership	0	0	0
		Third-party referrals	1	1	2
		Sci. / prof. activities	0	1	1
		Cold call	0	2	2
			1	4	5
	Pearson x^2 = 1.8750 (P-value = .392)				
	P-value of Fisher's exact = 1.000				

Table 8-12: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *BD-BD Contact* as a Moderator

			Categorical Alliance Performance		
			Low	High	
No BD-BD Contact	*Categorical Tie Strength*	Low	6	6	12
		High	8	11	19
			14	17	31
	Pearson x^2 = .1851 (P-value = .667)				
	P-value of Fisher's exact = .475				
			Low	High	
BD-BD Contact	*Categorical Tie Strength*	Low	8	2	10
		High	2	3	5
			10	5	15
	Pearson x^2 = 2.4000 (P-value = .121)				
	P-value of Fisher's exact = .251				

			Categorical Alliance Performance		
			Low	High	
No BD-BD Contact	*Alliance Origin*	Shared experience	2	2	4
		Shared membership	1	2	3
		Third-party referrals	4	1	5
		Sci. / prof. activities	5	7	12
		Cold call	2	4	6
			14	16	30
	Pearson x^2 = 3.0134 (P-value = .556)				
	P-value of Fisher's exact = .605				
			Low	High	
BD-BD Contact	*Alliance Origin*	Shared experience	0	1	1
		Shared membership	0	0	0
		Third-party referrals	2	0	2
		Sci. / prof. activities	2	3	5
		Cold call	6	1	7
			10	5	15
	Pearson x^2 = 5.7429 (P-value = .125)				
	P-value of Fisher's exact = .172				

Table 8-13: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *CSO-CSO Contact* as a Moderator

			Categorical Alliance Performance		
			Low	High	
No CSO-CSO Contact	*Categorical Tie Strength*	Low	13	8	21
		High	6	14	20
			19	22	41
	Pearson x^2 = 4.1934 (P-value = .041)				
	P-value of Fisher's exact = .062				
			Low	High	
CSO-CSO Contact	*Categorical Tie Strength*	Low	1	0	1
		High	4	0	4
			5	0	5
	Pearson x^2 = Unavailable				
	P-value of Fisher's exact = Unavailable				

			Categorical Alliance Performance		
			Low	High	
No CSO-CSO Contact	*Alliance Origin*	Shared experience	0	3	3
		Shared membership	1	2	3
		Third-party referrals	5	1	6
		Sci. / prof. activities	5	10	15
		Cold call	8	5	13
			19	21	40
	Pearson x^2 = 8.2797 (P-value = .082)				
	P-value of Fisher's exact = .075				
			Low	High	
CSO-CSO Contact	*Alliance Origin*	Shared experience	2	0	2
		Shared membership	0	0	0
		Third-party referrals	1	0	1
		Sci. / prof. activities	2	0	2
		Cold call	0	0	0
			5	0	5
	Pearson x^2 = Unavailable				
	P-value of Fisher's exact = Unavailable				

Table 8-14: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *Own Contact* as a Moderator

			Categorical Alliance Performance		
			Low	High	
Not Own Contact	*Categorical Tie Strength*	Low	2	6	8
		High	4	3	7
			6	9	15
	Pearson x^2 = 1.6071 (P-value = .205)				
	P-value of Fisher's exact = .315				
			Low	High	
Own Contact	*Categorical Tie Strength*	Low	12	2	14
		High	6	11	17
			18	13	31
	Pearson x^2 = 8.0155 (P-value = .005)				
	P-value of Fisher's exact = .009				

			Categorical Alliance Performance		
			Low	High	
Not Own Contact	*Alliance Origin*	Shared experience	0	0	0
		Shared membership	0	1	1
		Third-party referrals	1	0	1
		Sci. / prof. activities	1	3	4
		Cold call	4	4	8
			6	8	14
	Pearson x^2 = 2.7708 (P-value = .428)				
	P-value of Fisher's exact = .636				
			Low	High	
Own Contact	*Alliance Origin*	Shared experience	2	3	5
		Shared membership	1	1	2
		Third-party referrals	5	1	6
		Sci. / prof. activities	6	7	13
		Cold call	4	1	5
			18	13	31
	Pearson x^2 = 4.0423 (P-value = .400)				
	P-value of Fisher's exact = .414				

Table 8-15: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *Symmetrical Collaboration* as a Moderator

			Categorical Alliance Performance		
			Low	High	
Not Symmetrical Collaboration	*Categorical Tie Strength*	Low	7	4	11
		High	5	4	9
			12	8	20
	Pearson x^2 = .1347 (P-value = .714)				
	P-value of Fisher's exact = .535				
			Low	High	
Symmetrical Collaboration	*Categorical Tie Strength*	Low	7	4	11
		High	5	10	15
			12	14	26
	Pearson x^2 = 2.3449 (P-value = .126)				
	P-value of Fisher's exact = .233				

			Categorical Alliance Performance		
			Low	High	
Not Symmetrical Collaboration	*Alliance Origin*	Shared experience	1	1	2
		Shared membership	0	0	0
		Third-party referrals	3	1	4
		Sci. / prof. activities	4	3	7
		Cold call	4	2	6
			12	7	19
	Pearson x^2 = .5305 (P-value = .912)				
	P-value of Fisher's exact = 1.000				
			Low	High	
Symmetrical Collaboration	*Alliance Origin*	Shared experience	1	2	3
		Shared membership	1	2	3
		Third-party referrals	3	0	3
		Sci. / prof. activities	3	7	10
		Cold call	4	3	7
			12	14	16
	Pearson x^2 = .5305 (P-value = .912)				
	P-value of Fisher's exact = 1.000				

Table 8-16: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *Downstream Alliance* as a Moderator

			Categorical Alliance Performance		
			Low	High	
Not Downstream Alliance	*Categorical Tie Strength*	Low	11	5	16
		High	6	8	14
			17	13	20
	Pearson x^2 = 2.0386 (P-value = .153)				
	P-value of Fisher's exact = .145				
			Low	High	
Downstream Alliance	*Categorical Tie Strength*	Low	3	3	6
		High	4	6	10
			7	9	16
	Pearson x^2 = .1524 (P-value = 696)				
	P-value of Fisher's exact = .549				

			Categorical Alliance Performance		
			Low	High	
Not Downstream Alliance	*Alliance Origin*	Shared experience	2	2	4
		Shared membership	0	1	1
		Third-party referrals	5	1	6
		Sci. / prof. activities	5	5	5
		Cold call	5	3	8
			17	12	29
	Pearson x^2 = 3.4058 (P-value = .492)				
	P-value of Fisher's exact = .529				
			Low	High	
Downstream Alliance	*Alliance Origin*	Shared experience	0	1	1
		Shared membership	1	1	2
		Third-party referrals	1	0	1
		Sci. / prof. activities	2	5	7
		Cold call	3	2	5
			7	9	16
	Pearson x^2 = 3.2871 (P-value = .511)				
	P-value of Fisher's exact = .755				

Table 8-17: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *Assets* as a Moderator

			Categorical Alliance Performance		
			Low	High	
Low Assets	*Categorical Tie Strength*	Low	7	5	12
		High	2	8	10
			12	13	22
	Pearson x^2 = 3.3157 (P-value = .069)				
	P-value of Fisher's exact = .082				
			Low	High	
High Assets	*Categorical Tie Strength*	Low	7	3	10
		High	8	6	14
			15	9	24
	Pearson x^2 = .4114 (P-value = 521)				
	P-value of Fisher's exact = .418				

			Categorical Alliance Performance		
			Low	High	
Low Assets	*Alliance Origin*	Shared experience	0	1	1
		Shared membership	1	2	3
		Third-party referrals	3	1	4
		Sci. / prof. activities	3	3	6
		Cold call	2	5	7
			9	12	21
	Pearson x^2 = 3.2569 (P-value = .516)				
	P-value of Fisher's exact = .578				
			Low	High	
High Assets	*Alliance Origin*	Shared experience	2	2	4
		Shared membership	3	0	3
		Third-party referrals	0	0	0
		Sci. / prof. activities	4	7	11
		Cold call	6	0	6
			15	9	24
	Pearson x^2 = 8.8727 (P-value = .031)				
	P-value of Fisher's exact = .027				

Table 8-18: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *Stock Price* as a Moderator

			Categorical Alliance Performance		
			Low	High	
Low Stock Price	*Categorical Tie Strength*	Low	8	4	12
		High	2	9	11
			10	13	23
	Pearson x^2 = 5.4900 (P-value = .019)				
	P-value of Fisher's exact = .026				
			Low	High	
High Stock Price	*Categorical Tie Strength*	Low	6	4	10
		High	8	5	13
			14	9	23
	Pearson x^2 = .0056 (P-value = 940)				
	P-value of Fisher's exact = .637				

			Categorical Alliance Performance		
			Low	High	
Low Stock Price	*Alliance Origin*	Shared experience	0	2	2
		Shared membership	1	2	3
		Third party referrals	4	1	5
		Sci. / prof. activities	3	2	5
		Cold call	2	5	7
			10	12	22
	Pearson x^2 = 5.4825 (P-value = .241)				
	P-value of Fisher's exact = .315				
			Low	High	
High Stock Price	*Alliance Origin*	Shared experience	2	1	3
		Shared membership	2	0	2
		Third party referrals	0	0	0
		Sci. / prof. activities	4	8	12
		Cold call	6	0	6
			14	9	23
	Pearson x^2 = 9.0053 (P-value = .029)				
	P-value of Fisher's exact = .015				

Table 8-19: Results of Fisher's Exact Tests – *Tie Strength*, *Alliance Origin*, and *Alliance Performance* with *Net Income* as a Moderator

			Categorical Alliance Performance		
			Low	High	
Low Net Income	*Categorical Tie Strength*	Low	9	4	13
		High	3	7	10
			12	11	23
	Pearson x^2 = 3.4862 (P-value = .062)				
	P-value of Fisher's exact = .074				
			Low	High	
High Net Income	*Categorical Tie Strength*	Low	5	4	9
		High	7	7	14
			12	11	23
	Pearson x^2 = .0678 (P-value = .795)				
	P-value of Fisher's exact = .567				

			Categorical Alliance Performance		
			Low	High	
Low Net Income	*Alliance Origin*	Shared experience	1	3	4
		Shared membership	0	1	1
		Third-party referrals	2	0	2
		Sci. / prof. activities	4	6	10
		Cold call	5	1	6
			12	11	23
	Pearson x^2 = 7.0365 (P-value = .134)				
	P-value of Fisher's exact = .131				
			Low	High	
High Net Income	*Alliance Origin*	Shared experience	1	0	1
		Shared membership	1	1	2
		Third-party referrals	4	1	5
		Sci. / prof. activities	3	4	7
		Cold call	3	4	7
			12	10	22
	Pearson x^2 = 2.9281 (P-value = .570)				
	P-value of Fisher's exact = .579				

independence of *categorical tie strength* and *categorical alliance performance*, while the lower part shows it of *alliance origin* and *categorical alliance performance*. Each subtable has two analytical groups created with the moderating dummy indicators (i.e., high / yes and low / no). A summary of these tests is available in Table 8-20. While the second column in Table 8-20 contains results of Fisher's tests when the 12 dummy variables indicate either "low" or "no," the third column indicates those when they indicate either "high" or "yes." While the upper row of each subtable shows results for *categorical tie strength*, the lower presents those for *alliance origin*.

The findings from these Fisher's tests can be summarized as follows:

1. When organizations have a higher degree of *R&D experience*, *categorical alliance performance* is not independent of *alliance origin* ($p < .019$ in Table 8-5).
2. When organizations have a higher degree of *IOR experience*, *categorical alliance performance* is not independent of *categorical tie strength* ($p < .053$ in Table 8-6) and *alliance origin* ($p < .085$ in Table 8-6).
3. When alliances are not formed based on *CSO-CSO contact*, *categorical alliance performance* is not independent of *categorical tie strength* ($p < .041$ in Table 8-13) and *alliance origin* ($p < .075$ in Table 9-13).
4. When organizations form alliances based on their *own contact*, *categorical alliance performance* is not independent of *categorical tie strength* ($p < .003$ in Table 8-14).
5. For firms with smaller assets and lower stock prices, *categorical tie strength* is not independent of *categorical alliance performance* (i.e., $p = .082$ in Table 8-17 and $p = .026$ in Table 8-18).
6. For firms with greater assets and lower stock prices, *alliance origin* is not independent of *categorical alliance performance* (i.e., $p = .027$ in Table 8-17 and $p = .015$ in Table 8-18).

The first two findings imply the importance of collaborative know-how, not as

Table 8-20: Summary of Fisher's Exact Tests with Moderators (P-values)

	Low / No	High / Yes
R&D Experience		
Tie Strength	n.s.	n.s.
Alliance Origin	n.s.	**.019**
IOR Experience		
Tie Strength	n.s.	**.087**
Alliance Origin	n.s.	**.085**
Alliance Age		
Tie Strength	n.s.	n.s.
Alliance Origin	n.s.	n.s.
N of BD Professionals		
Tie Strength	n.s.	n.s.
Alliance Origin	n.s.	n.s.
Technical Intensity		
Tie Strength	n.s.	n.s.
Alliance Origin	n.s.	n.s.
Partner's Reputation		
Tie Strength	**.90**	n.s.
Alliance Origin	**.97**	n.s.
CEO-CEO contact		
Tie Strength	n.s.	n.s.
Alliance Origin	n.s.	n.s.
BD-BD Contact		
Tie Strength	n.s.	n.s.
Alliance Origin	n.s.	n.s.
CSO-CSO Contact		
Tie Strength	**.062**	n.s.
Alliance Origin	**.075**	n.s.
Own Contact		
Tie Strength	n.s.	**.009**
Alliance Origin	n.s.	n.s.
Symmetrical Collaboration		
Tie Strength	n.s.	n.s.
Alliance Origin	n.s.	n.s.
Downstream Alliance		
Tie Strength	n.s.	n.s.
Alliance Origin	n.s.	n.s.
Asset		
Tie Strength	**.082**	n.s.
Alliance Origin	n.s.	**.027**
Stock Price		
Tie Strength	**.026**	n.s.
Alliance Origin	n.s	**.015**
Net Income		
Tie Strength	**.074**	n.s.
Alliance Origin	n.s.	n.s.

one of the alternative uncertainty reduction mechanisms but as a factor for high-performing alliances (Simonin, 1997). As found in Tables 8-2 to 8-4, strength of ties between contact persons does not guarantee high-performing alliances. The finding here, however, implies that organizations are able to learn how to use personal rapport in resolving problems and improving alliance performance (Barkema et al., 1997; Powell et al., 1997; Simonin, 1997). Although the simple presence of personal rapport does not help two allying organizations run the alliances effectively, such rapport is useful when used wisely and appropriately. It is collaborative know-how that enables organizations to facilitate problem solution and manage interorganizational relations with the help of the relational mechanism and personal rapport. Indeed, in Table 8-5, *dummy tie strength* and *dummy alliance performance* are positively associated when organizations have a higher degree of *IOR experience*. The causal associations between personal rapport and alliance performance emerge only when organizations learn how to use rapport in resolving problems during the course of collaboration.

This interpretation is partially consistent with one of the findings in my fieldwork. One of the BD executives pointed out the importance of alliance experience in facilitating negotiation during alliance formation processes. Pre-existing and ongoing personal rapport does not always result in harmonious negotiation processes, particularly when the contact persons are not extensively and structurally involved in the negotiations. The executive needs to ask the contact persons to get involved in the processes in an appropriate way and at the right time so that two negotiating organizations are able to re-activate personal rapport for problem resolution. Judgement of how and when he brings contact persons to the process requires some intuitions and experience, because certain inevitable and unresolvable

problems may cause not only interorganizational but also personal conflict. In addition, when the strength of personal rapport is overestimated, it makes negotiation processes more complicated if such persons are brought into the processes. For instance, when the executive asked the contact person in his firm to speed up stagnated negotiation processes, it turned out that a business friend of the contact person in the negotiating firm had an internal political conflict with a manager who was primarily responsible for this collaborative project. Bringing personal rapport back to the table is a risky option because the manager in the partnering firm may want to discard the proposed alliances for his internal political reasons. The executive warned me that an easy reliance on personal rapport sometimes creates new problems in such cases. Although the case he provided is limited to the phase prior to alliance formation, it can be applied to the ways in which two allying organizations resolve problems. Organizations are able to gain the benefits of the relational mechanism and personal rapport between contact persons only when they accumulate alliance experience and learn how to use the ties in managing alliances.

A similar interpretation can be applied to the third finding on *CSO-CSO contact*: when contacts that initiate alliance formation processes are not between CSOs, *categorical alliance performance* is not independent of *categorical tie strength* and *alliance origin*. Although unavailability of half of the test results in Table 8-12 requires us to interpret this finding cautiously, it is found that when alliances initiate with non-CSO-CSO contacts, their original contact points change the degree of alliance performance and strength of ties between contact persons increases alliance performance.

It is primarily CSOs who interact with each other for interorganizational information / resource exchange and resolve daily problems in pursuing alliance goals. However, it is also true that CSOs are unable to resolve all the problems they encounter. CSOs may ask other personnel in management to provide their managerial judgement and decisions on such issues as budgeting, information disclosure, intellectual property, partners' strategic change, and environmental change (Arino & Torre, 1998). When there exists personal rapport between non-CSOs who help two organizations engage in alliances, the allying organizations may be able to go back to the contact persons and leverage the rapport in resolving these non-daily and relatively large issues (March & Simon, 1958). The personal rapport between non-CSOs is more important and more influential because problems to be resolved require a greater degree of coordination between organizations and adjustment to the changing environment. In other words, when two allying organizations build alliances upon certain personal rapport between non-CSOs, the rapport may be used for resolving larger managerial problems during the course of collaboration.

The fourth finding indicates that when responding organizations make first contact to initiate alliance formation processes, strength of ties between contact persons is positively associated with alliance performance. This finding may show strong effects of usage of perceptional data. Although a simple correlation between *alliance performance* and *own contact* is just -.07 in Table 8-1, it might be reasonable for contacting organizations to have positive opinions about alliances because they initiate the formation processes by activating personal rapport at their own discretion (Bradley, 1978; Kidd & Morgan, 1969; Miller & Ross, 1975; O'Reilly, 1983).

Finally, it is found that two financial indicators also moderate associations between the relational mechanism and alliance performance. For firms with smaller assets and lower stock prices, strength of ties between contact persons is not independent of alliance performance. On the basis of frequency in each cell in Table 8-17 and 8-18, it seems that tie strength increases alliance performance when firms are in financially weak positions. This interpretation is partially consistent with a finding of non-independence between *alliance origin* and *alliance performance*: for firms with greater assets and higher stock prices, alliances perform better when they emerge out of personal relationships between contact persons who originally met through professional and scientific activities and, supposedly, share fewer interactions prior to alliance formation.

Although any speculation and interpretation of these findings requires caution because of another finding in Table 8-17 and 8-18 – that for firms with greater assets and higher stock prices, alliance performance is poor when they emerge out of cold calls - it is reasonable that effects of pre-existing connectedness and sharedness at the individual levels on alliance performance become more manifest when firms face financially serious situations (Uzzi, 1996). As suggested in the embeddedness argument (Granovetter, 1985, 1991), this is probably because actors connected with those in serious situations are more willing to help them in economic transactions so as to obtain approval and sociability and reinforce pre-existing social relations. In addition, a finding on assets implies that, for smaller firms, ways in which organizations use personal social ties in economic transactions affect the economic performance. The importance of each individual actor is relatively greater in smaller firms than in larger firms (Kirzner, 1983; Ronen, 1983), so for smaller firms, pre-

existing personal ties are more influential in resolving problems in alliances and managing interorganizational relationships (Larson, 1992). In general, these findings provide new information to the embeddedness argument that effects of social ties in economic transactions on performance are contingent on degrees of firms' financial situations and that such effects become more manifest when firms are in more serious situations as well as have fewer assets.

8-2: Discussions and Limitations

In short, a series of analyses in Study 2 has revealed the following: (1) there is no simple association between the relational mechanism and alliance performance, however, (2) if we introduce moderators, then there is.

First, in order to increase alliance performance, it is necessary for organizations to use personal rapport wisely and purposefully so as to resolve problems in alliances. Although it is certain that personal rapport is useful for making first contact in forming alliances and provides certain norms of reciprocity that decrease likelihood of partners' malfeasance and opportunism after alliance formation (Larson, 1992), it does not automatically guarantee high alliance performance. This finding is congruent with Uzzi (1996, 1999), who finds that organizations perform better when they use both arms-length ties and the embedded ties operationalized by repeated transactions. This is because organizations are able to combine the strength of these two different types of ties: while arms-length ties provide economic efficiency and access to cutting-edge technology and the emerging market, embedded ties help organizations improve internal capability for innovation and problem solving through a high degree of interaction and communication. In addition, such partnering organizations are willing to respond to urgent requests from organizations whereby

such issues as shortage of supply and change of product design are dealt with flexibly. Uzzi's research, hence, contends that embedded ties do not automatically lead to high organizational performance. Both his and this research imply that what matters in determining performance is how organizations use personal rapport in economic transactions as well as whether it exists between allying firms.

Second, relating to the first point, this research found that, as organizations accumulate alliance experience and develop collaborative know-how (Barkema et al., 1997; Powell et al., 1996; Simonin, 1997), they are able to learn how to use rapport for resolving problems and improving alliance performance. This must be particularly important when contact persons who made primary contributions to alliance formation are not structurally involved in joint scientific projects and resource / knowledge exchange-processes. Inappropriate ways of bringing contact persons into problem-solution processes not only inhibit the processes, but also undermine the personal rapport. Myopic reliance on the relational mechanism is not necessarily helpful in solving problems.

Third, this research found that characteristics of first contact for alliance formation partially determine the importance of the relational mechanism in predicting alliance performance. This is interesting because it implies that organizations should be careful about how they make first contact to improve performance of alliances that have not been formed yet. The first contact not only predetermines available social communication channels for problem solution but also presets role expectations (Dyer & Singh, 1997). Organizations need to be careful at the first contact about how they attempt to preset roles.

Finally, this research demonstrated that effects of personal rapport on performance are moderated by financial situations of firms. Although the small number of observations in this research and relatively weak statistical significance in the analyses prompt the fear that an overemphasis of findings may cause confusion, these findings are consistent with the embeddedness approach in that when two economic actors have a long history of interactions and have developed reciprocity and empathy, they are willing to help each other when he or she is in serious situations. In addition, a finding of asset is also congruent with the previous argument that the role of social ties in executing business transactions becomes more marginal as organizational size increases (Granovetter, 1995).

These findings paint an interesting portrait of organizational life. Previous research suggests that organizations are able to transfer pre-existing norms of reciprocity and behavioral expectations and, therefore, facilitate interorganizational resource exchange by building interorganizational networks upon pre-existing personal rapport (Larson, 1992; Uzzi, 1996, 1999). However, this research did not provide full support to this claim: there is no obvious and direct linkage between the relational mechanism and alliance performance. For one thing, alliance performance should be viewed as not only how organizations form alliances, but also how organizations run and manage alliances (Arino & Torre, 1998; Dyer & Singh, 1997; Ebers, 1999; Ring & Van de Ven, 1993; Sobrero & Schrader, 1998). For another, effects of pre-existing personal rapport diminish as phases of alliances progress (Singh, 1997). The personal rapport facilitates and sustains resource-exchange processes at the beginning of alliances and increases managers' positive perception of alliance performance. However, as interactions between personnel in allying

organizations become complex, the role of the personal rapport becomes relatively less important. Hence, as phases of alliances progress, the relational mechanism may lose explanatory power over alliance performance.

In addition, this research claims that the personal rapport is useless in improving alliance performance unless organizations learn to use it wisely and purposefully. Organizations are not able to maximize benefits of personal rapport between contact persons without incorporating them into problem-resolution processes.

Furthermore, I failed to find the direct and obvious associations because personal rapport's positive effects may be cancelled out by its negative effects. While an advantage of using personal rapport in forming alliances resides in transferability of behavioral patterns and norms of reciprocity from the personal level to the organizational level, those who are strongly tied tend to have redundant information, resources, and technology, so reliance on personal rapport in forming alliances may constrain access to cutting-edge and heterogeneous technology usually valued in biotechnology alliances (Burt, 1992; Singh, 1997).

Although this research has no additional data that enable me to specify reasons for the absence of the direct and obvious associations, there is an agreement across these studies that managers should not simply believe in strong linkages between pre-existing personal rapport and alliance performance. This agreement also implies that some regional business networks do outperform others, but not only because of dense social networks that support and facilitate business transactions (Pyke, Becattini, & Sengenberger, 1990; Saxenian, 1994). Although it is certain, as found in this research as well as previous research, that pre-existing personal rapport can be seeds for

alliances and interorganizational networks, effects of the rapport on performance are not so simple that various factors must exist that moderate this causal mechanism. There must exist intraorganizational factors, interorganizational characteristics, and institutional mechanisms that effect the value of pre-existing personal rapport in economic transactions and interorganizational exchange. One of the contributions of this research is a finding of collaborative know-how as a moderator. Organizations become able to reap the benefits of the personal rapport and embedded ties in constructing and managing interorganizational networks as they accumulate relevant experience and develop collaborative know-how. Future research should explore other moderating factors and identify mechanisms in which organizations convert personal rapport into interorganizational rapport and high performing alliances.

This research has several limitations as well as suggestions for future research. First, alliance performance should be viewed as a function of how organizations form alliances and how organizations manage alliances after they form (Arino & Torre, 1998; Dyer & Singh, 1997; Ebers, 1999; Ring & Van de Ven, 1993; Sobrero & Schrader, 1998). Previous research indicates that when organizations are able to establish solid interorganizational problem-solution processes along the course of collaboration, they are more able to facilitate communication, resolve conflict, and develop norms of reciprocity and interorganizational trust necessary for continuing transactions. This research is biased in a sense that it has data only about how organizations form alliances, not manage them. Although lack of the latter data poses a limitation in generalizability and expandability of the findings, it should be emphasized here that a major contribution of this research resides in adding new knowledge to our understanding of the role of pre-existing personal rapport in

determining alliance performance, to which previous research has paid less empirical attention. However, it is also true that combining both types of data in future research will surely improve the explanatory power of alliance performance.

Second, as noted above, it is not desirable, but reasonable, to employ perceptional data about alliance performance. However, if it is available, researchers should combine different types of alliance performance data (e.g., dissolution of alliances, length of alliances, and managers' perception of alliances) (Gulati, 1998). Such an approach would enable us to view multidimensional aspects of alliance performance. For instance, pre-existing personal rapport may be helpful only in bonding two allying firms and extending the duration of alliances. If so, the relational mechanism may not be directly associated with perceived alliance performance as found in this research, but significantly enhance length of alliances, another dimension of alliance performance. In addition, collecting perceptional data from different groups of personnel in allying firms is also important because such perceptions should be sensitive to internal roles and positions (Tsui & Milkovich, 1987).

Third, there is also a theoretical concern. It is still not clear whether embedded ties are useful for alliance performance as well as organizational performance. After reviewing a number of previous studies, Gulati (1998) concludes that embedded ties are useful for improving alliance performance. On the other hand, as reviewed above, Uzzi (1996, 1999) claims that organizations do not perform well when they depend only on the embedded ties in constructing exchange networks.

These two conclusions are inconsistent: while embedded ties are helpful for improving alliance performance, they are not always helpful for improving organizational performance. A cause of this inconsistency must be that organizational

performance is not, and should not be viewed as, a simple accumulation of alliance performance. Rather, it is a function of both internal resources and idiosyncratic interorganizational linkages (Dyer & Singh, 1988). Currently, however, there is no conceptual model available that articulates complex interactions between these two levels of performance. Still little is known about how embedded ties play different roles in determining alliance and organizational performance and how and under what condition alliance performance is related to organizational performance.

Another question that the inconsistency poses is the meaning of embedded ties. In previous research, embedded ties are operationalized with such organizational-level data as duration of interorganizational relations and repeated transactions. However, because any relation starts with certain personal contact (Larson, 1992; Gulati & Gargiulo, 1999), researchers should expand their scope of research to add the individual-level data that describe personal histories of interactions as a source of interorganizational relations. Although this research may be one of the first efforts that systematically collect the individual-level data in accounting for alliance performance, further efforts are required to integrate the individual- and organizational-level data and articulate the meaning and operationalization of embedded ties. In doing so, ongoing discussions on multilevel theory building should be useful and helpful (Klein, Tosi, & Cannella, 1999; Morgeson & Hofmann, 1999). The most important advantage of multilevel theories resides in descriptions and articulations of "some combination of individuals, dyads, teams, businesses, corporations, and industries" (Klen et al., 1999: 243) and enables us to provide a deeper and richer portrait of organizational phenomena. An initial effort has already been made by Zaheer, McEvily, and Perrone (1998) in which they examine effects of

both interpersonal and interorganizational trust on alliance performance and find different roles for each type of trust in determining exchange performance. Future research that focuses on the multilevel analyses should advance our understanding of alliance performance and the embedded nature of economic organizations.

Finally, while this research found that collaborative know-how moderates associations between the relational mechanism and alliance performance, further research is required to comprehend exactly what organizations learn as a result of accumulating alliance experience. At this point, it is only Simonin (1997) who attempted to identify components of organizational know-how for running alliances. He contends that collaborative know-how consists of (1) identification and selection of appropriate partners, (2) negotiation, (3) collaboration and resource exchange, and (4) termination of alliances. However, more-detailed information about the contents of learning should be obtained so that researchers can suggest how organizations should use personal rapport for improving alliance performance and what helps them procure such know-how. It is certain that qualitative data from fieldwork will enable us to explore these issues and identify the exact contents of collaborative know-how (Pinch, 2000).

This chapter presented results of testing hypotheses on associations between alliance performance and the relational mechanism. In Chapter 4 I hypothesized that use of the relational mechanism in forming alliances can either increase or decrease alliance performance. For one thing, the relational mechanism may restrict organizational access to heterogeneous and nonredundant resources and knowledge outside organizational boundaries. For another, it may enable allying organizations to transfer behavioral expectations and norms of reciprocity developed from prior

interactions to ongoing alliances so as to decrease the likelihood of partners' malfeasance and opportunism. Statistical analyses in this chapter demonstrated that (1) there exists no direct and obvious association between them and (2) the associations emerge when moderating factors are introduced into the analytical models, which include (1) collaborative know-how, characteristics of contact persons, and firms' financial conditions. One of the implications of these findings is that just the presence of pre-existing personal rapport does not help organizations achieve high alliance performance. By accumulating alliance experience and developing collaborative know-how, organizations are able to learn how to use it wisely and purposefully in order to resolve problems in alliances.

CHAPTER NINE: DISCUSIONS AND CONCLUSIONS

Because the theoretical meanings and limitations of each analysis were provided in separate chapters above, I concentrate here on discussing the fundamental contributions and implications of this research.

9-1: Research on Uncertainty

This research demonstrated the need for integrating traditional and contemporary organization research on organizational management of uncertainty (Thompson, 1967). Organizations can be viewed as a human-created device for managing and reducing uncertainty. A number of studies have been published since the open-system approach was introduced that focus on internal structures enabling organizations to manage internal coordination and environmental turbulence, both of which cause uncertainty problems (i.e., Galbraith, 1973). In addition, recent research, particularly in interorganizational relations research, emphasizes the role of networks and contexts in reducing uncertainty in which organizations are embedded (Davis & Powell, 1992; Galaskiewicz, 1985; Larson, 1992; Nohria & Gulati, 1994; Podolny, 1994; Powell & Smith-Doerr, 1994; Uzzi, 1996, 1999). However, the former approach tends to focus on just internal structures (e.g., boundary spanning) but overlook the embedded nature of organizations. At the same time, the latter approach tends to stress the importance of contexts and network structures but leave internal structures and capabilities out of its scope. This tendency is particularly manifest in research using network analyses that occasionally treats organizations as actors in networks without making definite distinctions between individuals, groups, and organizations.

Organizations are certainly actors in larger networks and contexts (Granovetter, 1985, 1991; Swedberg & Granovetter, 1992). However, organizations are also actors in networks with internal devices that reduce uncertainty and sometimes change the meaning and role of larger networks and contexts. Reliance on one of the approaches in uncertainty research captures just one side of organizational life.

This claim is not new, but just a renewal of Emery and Trist (1965) and Terreberry (1968). These scholars assert that 3 exist three components in analyzing organizational relations with the environment and organizational management of uncertainty: (1) intraorganizational factors, (2) relations between the focal and other organizations, and (3) relations between other organizations. They suggest that researchers should address all of the following 3 questions: (1) how organizations internally make an effort to reduce uncertainty, (2) how organizations manage relations with other organizations to reduce uncertainty, and (3) how organizations manage an environment consisting of a set of other organizations to reduce uncertainty. It seems that research on uncertainty has failed to act on its their claim and expand its scope of analysis to include various approaches in examining organizational management of, and dynamic adaptation to, the environment. While this research may have made a contribution by demonstrating interrelatedness of the intraorganizational, relational, and contextual factors, a further integration is required of intraorganizational, interorganizational, and institutional mechanisms that relate to organizational management of uncertainty (Thompson, 1967).

Because this research focused on uncertainty that biotechnology firms face in selecting R&D alliance partners, limited generalization of its findings must be

acknowledged. Many additional areas exist for future study about mechanisms that enable organizations to reduce selection uncertainty. In addition to expanding the scope of research to include selection of R&D alliance partners in other industries (e.g., semiconductor, automobile parts, and software), future research could strengthen generalization of this research by examining other forms and different levels of selection uncertainty.

For one thing, organizations face other types of selection uncertainty in selection of boards of directors, employees, suppliers, distributors, consultants, and the like. Although ways in which firms use social networks in hiring new employees have been examined since 1973, when Granovetter (1973) first published his research on weak ties, there are still no decisive answers for variations of organizational usage of social networks in recruitment and selection.

For another, future research will be able to examine individual levels of selection uncertainty. For instance, it should be informative if research analyzes how academic scholars select research partners and whether pre-existing relationships between them influence performance of their research (e.g., measured by the number of times it is cited). As discussed in Chapter three, by accumulating experience in selection, individual decision makers are able to develop collaborative know-how and routines for assessing prospective partners. Given that this causal mechanism can be applied to other contexts in individual life, most of the findings on the 3 mechanisms can be applied to research on patterns according to which individuals find partners and establish relationships. These 2 empirical efforts would advance our understanding of organizational, social, and individual mechanisms for reducing selection uncertainty in various situations.

9-2: Research on Ties and Embeddedness

The "beneficial tie" argument points out that (1) organizations are able to transfer norms of reciprocity and behavioral expectations developed through pre-existing interpersonal interactions to interorganizational relations, (2) organizations use pre-existing ties to exchange "private" information prior to alliance formation in reducing selection uncertainty, (3) allying organizations that have been previously tied are able to engage intensively in problem resolution, and (4) organizations are able to avoid an issue of partners' malfeasance and opportunism by constructing interorganizational networks upon pre-existing ties (Larson, 1992; Granovetter, 1973, 1985; Gulati, 1998; Uzzi, 1996, 1999). For instance, Ingram and Roberts (1999) find that friendship networks among the Sydney hotel managers increase the economic performance of hotels through enhancing interorganizational collaboration (e.g., sharing of overflow customers), mitigating competition, and providing channels of information exchange (i.e., price and occupancy information on a daily basis). Their research highlights an instrumental value of friendship networks that increases levels of trust, empathy, and reciprocity as social control mechanisms and contributes to economic transactions between organizations.

However, findings in the fieldwork, the archival-data analysis, and the mail-survey analysis did not lend strong support to this argument but shed light on new aspects of the role of pre-existing ties in economic exchange. Interviewees in the fieldwork did not particularly emphasize the importance of pre-existing personal rapport in forming alliances. Although they agreed that it is additionally beneficial if there exists certain personal rapport with prospective alliance partners, it is not a

serious problem if it does not. In addition, they did not consider an issue of opportunism and malfeasance seriously.

The archival-data analysis demonstrated that levels of multiplexity between allying firms in the biotechnology industry are weak. It seems that, with some exceptions, allying firms do not necessarily share a history of interactions prior to alliance formation. In addition, the regression analyses also revealed that the role of ties as the uncertainty reduction mechanism decreases as organizations develop the internal mechanisms, an alternative reduction mechanism.

The mail-survey data analysis also uncovered the fact that there do not exist simple and obvious associations between the relational mechanism and alliance performance. Alliance performance neither decreases nor increases: it does not depend on whether organizations form alliances upon strongly tied personal relations or on how the persons originally met who initiated alliance formation processes. The associations between the relational mechanism and alliance performance emerge only when certain moderators are introduced into the analytical models.

However, these findings do not reject previous claims of embeddedness. For one thing, although an original claim of embeddedness by Granovetter (1985, 1991) emphasizes the importance of personal-level ties (or *relational embeddedness* in his terms) in economic transactions, he also points out the importance of structures, norms, and contexts (or *structural embeddedness* in his terms) that indirectly provide constraints on, and opportunities, to economic actors. Relational embeddedness stresses the role of direct cohesive ties, whereas structural embeddedness depicts values derived from network positions that actors occupy (Burt, 1992). It is not only cohesive ties but also the structure of networks in which economic actors are

embedded that determine levels of available resources and access to opportunities. While this research partially considered an issue of contexts by incorporating the contextual mechanism and reputation, there must exist a number of factors left out of the arguments (see below also).

For another thing, this research found some aspects of strength and benefits in pre-existing ties in initiating new interorganizational relations. Interviewees in the fieldwork indicated that pre-existing rapport makes it easier for organizations to make contact in initiating discussions with prospective partners. The archival-data analysis demonstrated that organizations are able to form alliances with high-status organizations when they have previous multiplexity. Ties are still important in forming alliances and making contact, because prospective partners, who may receive a number of other contacts for alliance opportunities, pay more attention to organizations having certain previous connections.

Nevertheless, it is important to emphasize that this research highlighted an aspect of organizational life that has not been stressed in previous research taking the embeddedness approach: the meaning and role of a prior history of interactions in economic transactions vary according to the contents or nature of the transactions and availability of alternative mechanisms that substitute for prior interaction. In this sense, this research expands previous arguments in the embeddedness approach by revealing the variations in organizational reliance on a prior history of interactions or simply variations in economic transactions and by identifying factors that determine the importance of a prior history of interactions. This argument provides a direction for future research on the embedded nature of business transactions. While this research suggests that collaborative know-how replaces the role of social ties and a

prior history of interactions in selecting alliance partners and forming alliances, there must be different types of mechanisms in different contexts. Is there any other mechanism that changes the values of embeddedness in economic transactions? How do different types of problems that organizations face change the values of embeddedness in economic transactions? In examining these questions, a claim by Granovetter (1985) provides a pivotal guide: economic actors are embedded in ongoing social relations because they seek prestige, power, approval, friendship, and reciprocity in economic transactions. However, he does not speculate under what conditions and to what extent economic actors value social relations in conducting business transactions. While it was one of the important contributions of the embedded approach to find that "business" is not always "business," it is time to treat "embeddedness" as a variable (Uzzi, 1996, 1999), rather than a simple academic program, and examine under what conditions business becomes "nonbusiness."

9-3: Research on Interorganizational Relations

The findings from this research make several contributions to literature on interorganizational relations. First, while previous research tends to focus on organizational activities after alliance formation and examine ways of organizational management of alliances, this research and, particularly, the qualitative study revealed organizational activities prior to alliance formation and examined organizational effort to reduce selection uncertainty and form alliances. This contribution is important; while we have known that creating the win-win situations and increasing complementarity of allying firms are important for high-performing alliances, little has been known about processes by which organizations do so.

Second, previous research studying alliance formation is limited to an examination of repeated ties (Gulati, 1995; Gulati & Gargiulo, 1999). In addition, little has been shown concerning dynamics of networks, meaning how organizations change patterns of network construction (Powell & Smith-Doerr, 1994). This research provided information on how organizations find new alliance partners and descriptions of how persons initiating new alliances are socially and previously connected by employing the qualitative approach and mail surveys. The findings demonstrate, as opposed to those in previous research (Larson, 1992; Uzzi, 1996, 1999), that in some, but not all, cases, organizations start new interorganizational relations from cold calls. In addition, this research examined what determines the choice of partners with whom organizations form alliances by using the concept of multiplexity and revealed that as organizations accumulate experience and develop collaborative know-how, partners tend to become those with weak multiplexity and lower reputation.

Third, relating to the second contribution, it is now an emerging research agenda to treat embeddedness as a variable and examine determinants and consequences of organizational embeddedness (Block, 1990; Uzzi, 1996, 1999). Given that multiplexity is not only a proxy for the relational mechanism but also for organizational embeddedness that describes organizational dependence on previous shared interactions in economic transactions (Block, 1990), it is reasonable to claim that this research examined determinants of organizational embeddedness. The findings here claimed that organizational embeddedness, when operationalized as multiplexity, decreases as organizations accumulate alliance experience and develop collaborative know-how.

Fourth, previous research points out close linkages between reputation / status and alliance formation (Podolny, 1995; Stuart, 1998; Stuart et al., 1999). This research supported a previous finding that organizations certainly use reputation / status in selecting alliance partners because it signals credibility of prospective partners and reduces selection uncertainty. However, this research also found that not all organizations necessarily rely on reputation / status in reducing selection uncertainty. Rather, as organizations develop collaborative know-how, partners tend to be those with a lower reputation, so collaborative know-how replaces the role of reputation in selecting alliance partners. This research highlighted the fact hat the role and meaning of reputation in forming alliances are contingent on the degree of collaborative know-how.

Fifth, previous research does not examine associations between alliance performance and pre-existing personal rapport between allying firms (Gulati, 1998). This is theoretically interesting because researchers are able to learn the role and meaning of cohesive ties at the individual level in economic transactions. This is also practically interesting because managers are able to learn to what extent they should pay attention to levels of pre-existing personal rapport in selecting alliance partners and forming alliances. This research, by using mail-survey data, found that there exists no direct and obvious association between alliance performance and pre-existing personal rapport and that the association emerges only when some moderators are introduced into the analytical models.

Sixth, one of the findings in the quantitative research is that when partners have a higher reputation and status, relationships between organizations and partners are more likely to have higher degrees of multiplexity. This implies that pre-existing

ties are helpful for organizations in removing status differences that make it difficult for organizations to form alliances with highly reputable organizations. I also found that more investment in R&D activities signals organizations' potential growth in future and enables them to form alliances with prominent organizations.

Stuart et al. (1999) finds that when entrepreneurial firms form alliances with highly reputable pharmaceutical and biotechnology firms, the alliances provide endorsements and credibility to entrepreneurial firms' products and technology so that they are more able to increase capabilities of resource procurement and likelihood of organizational survival.

Although their research does not discuss how such entrepreneurial firms, which should experience difficulties in approaching prominent firms due to the status differences, can form alliances with prominent pharmaceutical and biotechnology firms, my findings suggest that, in an attempt to form alliances with prominent firms and remove the status differences, entrepreneurial firms are able to develop personal networks with individuals at prominent firms and build interorganizational networks upon these newly established personal networks. There should be several strategies available for entrepreneurial firms to develop such personal networks purposefully and intentionally. Firms may send their scientists and business professionals to scientific and business conferences and workshops, hire senior executives as network makers who have long experience in the industry, or work with professors who have connections with the industry.

My finding on the signaling effect of investment in R&D activities also suggests that entrepreneurial firms are more able to gain access to prominent firms by signaling their potential growth. As found in the quantitative analysis, advertising and

signaling their intensity in R&D activities and strong interest in collaboration are one of the strategies. Another possible strategy may be that firms form scientific boards in which university scholars assess and suggest firms' research activities and R&D strategies. Because university scholars are viewed as third parties independent of firms' commercial success and are supposed to have cutting-edge knowledge in the field, the presence and, more importantly, composition of scientific boards signal intensity of firms in R&D activities to the environment, which ultimately enables them to approach prominent organizations.

Findings in this research, therefore, lend potential insight into Stuart et al. (1999). However, still little is unknown as to how entrepreneurial firms strategically construct new personal networks and to what extent and under what conditions they are able to start business transactions out of the strategically designed social networks. Moreover, future research should examine how organizations signal and advertise their technology and intensity of R&D activities and how such signaling activities influence organizational capabilities of constructing interorganizational networks.

Finally, this research also presents some insights to the literature on evolutionary processes of interorganizational networks (Gulati & Gargiulo, 1999; Powell et al., 1996). The greatest volume of research in this stream centers on historical development and longitudinal transformation of interorganizational networks, analyzing linkages between development of interorganizational networks and changes of network components and network positions of each component. For instance Gulati and Gargiulo (1999) find that organizations expand their networks by using prior partners, common third parties, and other organizations with similar levels of centrality in alliance networks and that interorganizational networks develop with a

strong dependence on information from the networks of prior alliances to reduce selection uncertainty. Powell et al. (1996) find the learning cycles of networking, meaning that prior entry into alliance networks enables organizations to make further engagements in interorganizational collaboration, which results in their increased centrality in alliance networks.

Network portfolio (Gulati, 1998) is a useful analytical tool for describing the evolutionary processes and ways in which organizations design components of interorganizational networks. For instance, Uzzi (1996) finds that manufacturers in the fashion industry are more likely to survive when they design well-balanced networks that consist of the arms-length ties and the embedded ties involving long-term relationships. Network portfolio is a concept that portrays the proportion of certain types of exchange partners as components in interorganizational networks.

Findings in the quantitative analyses suggested that accumulation of alliance experience and development of collaborative know-how transform network portfolio: while network components of organizations with lower degrees of collaborative know-how are those with which they have higher degrees of multiplexity and who have a higher reputation, organizations with higher degrees of collaborative know-how tend to have as their network components those with which they have lower degrees of multiplexity and that have not earned higher degrees of reputation.

In addition, findings in the qualitative analyses suggested that network portfolio is linked with organizational life cycles and strategic changes. Organizations in different stages of their life cycles view alliances differently and use them differently to achieve their own strategic objectives. For instance, as found in Stuart et al. (1999) and substantiated by comments of one of the interviewees, entrepreneurial

firms view alliances as opportunities to obtain endorsements and increase the credibility of their technology and products, making it easier to procure resources. Such firms attempt to form research-outsourcing alliances with large established pharmaceutical firms, not only because they have cash but also provide better endorsements. On the other hand, firms also use other firms' capabilities to (1) enter new product markets by applying their fundamental technological (or marketing) capabilities and combining them with partners' marketing (or technological) capabilities and (2) strengthen fundamental technological platforms through sharing knowledge and exchanging information with alliance partners (Powell et al., 1999).

Given that organizations at different stages in their life cycles have different strategic objectives, they have different motivations in forming alliances and face different degrees and types of selection uncertainty. Types and extent of selection uncertainty to be removed should influence selection of alliance partners and ultimately components of interorganizational networks. For instance, organizations attempt to focus more on prospective partners' technical competence than their contributions for proposed collaborative projects that involve fewer interactions between scientists and researchers across organizational boundaries. In such cases, organizations may rely more on the contextual mechanism than the relational mechanism because it informs them of prospective partners' technological performance in the past. Therefore, selection of alliance partners and components of interorganizational networks are also dependent upon motivations for forming alliances and, more importantly, different strategic objectives.

Future research should examine how these two factors independently affect network portfolio and evolutionary processes of interorganizational networks.

Because development of collaborative know-how should be highly correlated with organizational life cycles (i.e., entrepreneurial firms should have lower degrees of collaborative know-how), it is uncertain at this point how these two factors really transform network portfolio and why (or why not) organizations change components of their networks. In doing so, researchers should pay more attention to transforming network portfolio of failing organizations (Meyer & Zucker, 1989). Because of the difficulty in collecting data, the two papers reviewed above, as well as this research, removed patterns of network formation and development of interorganizational networks of failing organizations from their scope of analysis. Little is known about whether there exists any difference between surviving and failing organizations in terms of transforming patterns of network portfolio and how network portfolio changes as organizations decline.

9-4: Learning and Interorganizational Relations – The Virtualization Model

The virtual-organization model is one of the recently proposed business models: organizations form and resolve temporary interorganizational networks that provide organizations access to best competencies and resources available in the environment. Organizations are able to utilize competencies and resources outside organizational boundaries without vertical integration. Virtual organizations are flexible and agile in the sense that they are able to adapt to a changing environment and emerging technologies without internally restructuring themselves and expanding their organizational boundaries.

A problem of this model resides in its neglect of selection uncertainty: organizations somehow manage to reduce selection uncertainty. When organizations depend on the relational mechanism in doing so, they are less able to gain access to

technologies and resources at other organizations with which they do not have any previous social and economic relations. When organizations depend on the contextual mechanism in doing so, they are less able to gain access to technologies and resources at such organizations as entrepreneurial firms and firms with emerging technologies that typically have not achieved a high reputation.

As found in this research and shown in Figure 9-1, as organizations accumulate alliance experience and develop collaborative know-how, they become less dependent on the relational and contextual mechanisms in reducing selection uncertainty and more able to select partners that have neither been previously connected to them nor achieved a high reputation. In this sense, this research uncovered that collaborative know-how is one of the important factors that drive organizations to virtualization. This learning effect should recycle: as organizations learn how to select appropriate partners and how to run alliances, they become more competent in forming alliances with those with weaker multiplexity and a lower reputation, whereby they accumulate new experience relevant to developing collaborative know-how further. These findings are partially consistent with Powell et al. (1996), in which they found that organizations move to central positions in interorganizational networks as they accumulate alliance experience. This is probably because development of collaborative know-how makes previously unreachable organizations reachable, with the result that they become able to expand their networks with less constraint and increase centrality in networks.

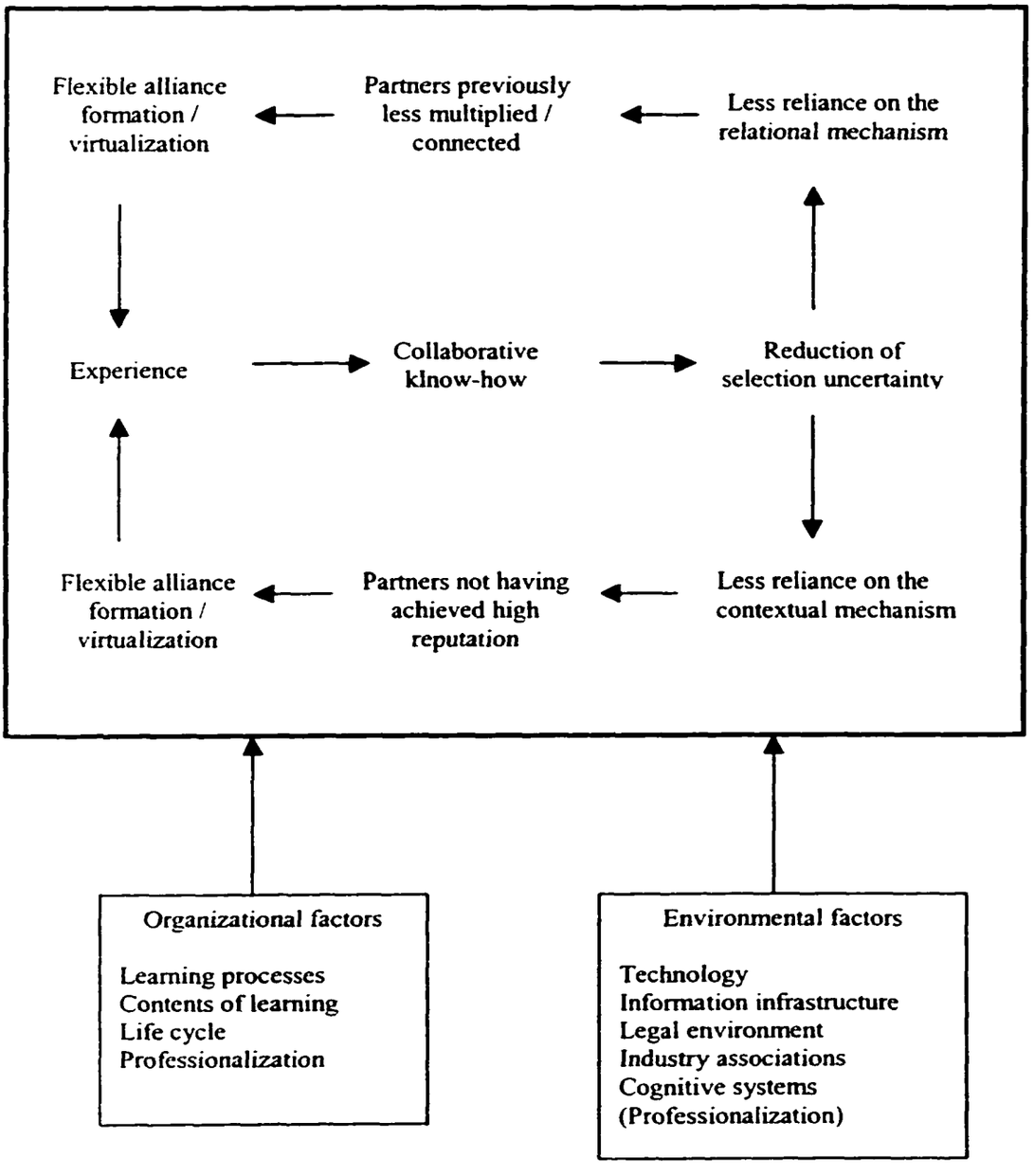

Figure 9-1: The Virtualization Model

Although a contribution of this research resides in an exploration of connections between organizational learning and interorganizational relations, this research and particularly the quantitative analyses also failed to examine other intraorganizational and environmental factors that should be relevant to virtualization of organizations. The model of virtualization is not complete without incorporating 4 intraorganizational and 5 environmental factors into the analytical schemes (see the lower part of Figure 9-1).

The first and second intraorganizational factors are learning processes and contents of learning. This research, following previous research (Barkema et al., 1997; Powell et al., 1996; Simonin, 1997), presumed a tight linkage between accumulation of alliance experience and development of collaborative know-how. However, before presuming such a linkage, researchers should examine how organizations transform experience into organizational knowledge and how and what organizational members learn from experience (Nelson & Winter, 1982; Stinchcombe, 1990). Although it has been believed that organizational members are able to learn by doing and develop routines to cope with problems and conserve cognitive resources for decision making (Cohen & Levinthal, 1990; Levitt & March, 1988; Pennings, Barkema, & Documa, 1994), recent research by Haleblian and Finkelstein (1999) suggests the need for reconsideration and articulation of this simple belief. They examine associations between merger and acquisition experience and organizational performance and find that organizational experience of merger and acquisitions improves organizational performance only when the organizations have accumulated similar and homogeneous experience relevant to a case they currently deal with. Their

finding implies that researchers should be careful about the degree of heterogeneity or homogeneity of experience as a source of learning: when experience is heterogeneous, it is less likely that organizations are able to learn by doing.

In addition, experience is not the only way for organizations to learn (Huber, 1991; Levitt & March, 1988). Organizations institutionalize new routines by imitating other organizations and incorporating their programs, procedures, and routines. Previous empirical research shows evidence of such learning in the following areas: (1) organizational strategy (Davis, 1991; Greve, 1995; Haunschild, 1993; Haveman, 1993; Kraatz, 1995), (2) judgement and assessment of other organizations in the environment (Galaskiewicz & Burt, 1991), and (3) organizational structures (Burns & Wholey, 1993; Fligstein, 1985; Palmer, Jennings, & Zhou, 1993). Also, organizations are able to implement new routines by grafting (Aldrich & Pffefer, 1976; Boeker, 1997). Learning by grafting means that "organizations frequently increase their store of knowledge by acquiring and grafting on new members who possess knowledge not previously available within the organizations" (Huber, 1990: 97). Boeker (1997) for instance find that hiring new executives significantly changes organizations' strategy formations and entries into new product markets because new executives bring new know-how, knowledge, and information. These arguments imply that, in addition to learning by doing, a close examination should be conducted of other ways of learning and the effects on alliance formation patterns.

Furthermore, it is generally BD professionals who accumulate alliance experience. There is an agreement in previous research, however, that certain mechanisms are required for organizations to transfer individual intuition or skills to organizational routines and to memorize individual know-how as organizational

(Anand, Manz, & Glick, 1998; Adler, 1992; Moorman & Miner, 1998; Nonaka, 1998; Walsh & Rivera, 1991). For instance, it is now well known that the Japanese lean production system transforms workers' individual know-how on assembly lines to standard operating procedures for improving the pre-existing production process or reducing defect rates by encouraging their involvement in problem-solving activities (i.e., *kaizen*, or quality-control circles) (Adler, 1992; Appelbaum & Batt, 1994; Detrouzos, Lester and Solow, 1989; Hackman and Wageman, 1995; Womack, Jones, and Roos, 1991). The lean production system enables the workers, who are the most knowledgeable about their work, to make suggestions for improvement, create and implement new procedures, and share their know-how with other organizational members: "QC (quality control) circles are a way of recognizing that the information and knowledge that hourly workers have can contribute to process improvement and are an important form of employee involvement" (Appelbaum & Batt, 1994: 34). In order for organizations to transfer individual alliance experience to collaborative know-how as organizational routines, organizations may implement certain knowledge-transfer mechanisms or programs.

The third intraorganizational factor is life-cycle stages of products that organizations propose for collaborative projects with alliance partners. Organizations have different purposes in alliance formation, partially contingent on the life cycle of products on which they work: while some firms are interested in expanding the downstream capabilities (i.e., manufacturing, marketing, and distribution) when they search for partners, others attempt to build strong technological platforms and enhance their upstream capabilities (i.e., research and development) through procuring technological competence from partners. Previous literature implies that alliances for

upstream collaborative projects (i.e., R&D alliances) require more interactions between scientists, researchers, and engineers and a higher degree of interorganizational trust than do those for downstream projects (Badaracco, 1990; Gulati, 1995; Hennant, 1988). This is because lack of knowledge about sets of skills and knowledge necessary for completing upstream projects makes it more difficult to stipulate in advance the role of each of the allying firms and the amount and contents of knowledge and information to be exchanged. In general, therefore, collaborative upstream projects should pose a higher degree of selection uncertainty and that of pre-existing trust between organizations and thus affect the role of the relational mechanism in forming alliances (Gulati, 1995).

The fourth intraorganizational factor, which is also an environmental factor as well, is the effect that the professionalization and growth of business development as an occupation has on alliance formation. Although I could not obtain any significant findings from statistical analyses, a contribution of this research and, particularly, the fieldwork in this line lies in a finding that BD professionals are network managers and boundary spanners who scan the environment, identify prospective partners, and select appropriate partners. BD professionals in organizations enable scientists and top managers to focus on their internal work and protect them from environmental turbulence. It is also found that BD professionals share a culture that encourages them to exchange information openly and allows them to make cold calls in contacting new prospective partners. Growth of business development as an occupation should have an effect on the ways in which organizations reduce selection uncertainty and on patterns of alliance formation. However, we can say little about historical background and the effects of the increase of BD professionals on patterns of alliance formation

except for making a conjecture that the profession probably started in the semiconductor industry and was imitated in the biotechnology industry when it started around 1980 (Ryan et al., 1985). We also do not know what mechanism creates and maintains norms and disciplines in this profession and how professionals procure knowledge and routines and receive training to become network managers.

Regarding environmental factors, the first one is technology. Granovetter (1991) notes that the role of ties decreases in economic transactions when actors seek certain specific and advanced technology. Individuals and organizations in a dynamic technological environment need to gain access to emerging and cutting-edge technologies in order to catch up with technological development. Under such circumstances, economic actors make an approach to resource and technology holders, whether or not they are strongly tied and have known each other for a long time. Granovetter's argument is consistent with one of my findings in the fieldwork: one of the interviewees stressed that biotechnology is not a commodity industry where each firm has its own unique technology. He does not mind making cold calls and approaching total strangers because he has to do so in order to gain access to technologies that they possess. A conclusion in Stuart (1998) supports this comment, in that he finds that technologically distanced firms are more likely to form alliances than technologically close firms.

These arguments imply that organizational patterns of alliance formation and usage of social ties in forming alliances are contingent on both (1) speed of technological development and (2) spread of technologies in organizational space. Organizations may be less dependent on the relational mechanism in industries where technological development is more dynamic and each organization possess more

heterogeneous technologies and resources. When services and products are homogeneous in industries, organizations may be more dependent on the relational mechanism in forming alliances. However, this is not only because pre-existing rapport helps organizations reduce selection uncertainty, but also because economic actors seek sociability and approval in conducting economic activities (Granovetter, 1985).

The second environmental factor is information infrastructures. When information infrastructures are well developed in researching prospective partners, organizations may be less dependent on the relational and contextual mechanisms. Developed information infrastructures are a necessary condition for network managers and BD professionals to conduct internal research on prospective partners and reduce selection uncertainty with the internal mechanisms. BD professionals in the biotechnology industry constantly read industry journals (e.g., *Pharma Projects*, *R&D Focus*, *BioWorld*, *BioCentury*, and *Pharmaceutical Executive*), collect information from the Internet, and use commercial databases (e.g., *Bioscan*, *Windhover's Strategic Intelligence Systems*, *Recombinant Capital's Biotech Alliance Database*) in scanning the environment and researching prospective partners. These information infrastructures make it easier for organizations to procure information on prospective partners' ongoing research projects, stages of clinical trials, prior histories of alliances, both scientific and commercial outputs, intellectual property, and financial conditions. Although information from the infrastructures is only what is publicly available, it is still useful for reducing selection uncertainty and decrease the role of the relational and contextual mechanism in forming alliances, for the value of ties and reputation as

an information source in industries where information infrastructures are well developed may be lower than in those where they are not.

It is certain that the reliability of publicly available information from prospective partners varies: some organizations intentionally disseminate biased information favorable to themselves in order to obtain attention and acceptance from the environment and, particularly, financial markets. In addition to the amount of publicly available information and presence of infrastructures that support information dissemination, the credibility and the reliability of information sources are also crucial in valuing and assessing prospective partners.

In general, it is difficult for actors facing high uncertainty to judge credibility, quality, value, reliability, and safety because it requires them to possess specific knowledge and comprehension of technologies and processes. In such cases, certification, approvals, and permits from authorities and mutual third parties are useful in signaling levels of reliability and competence of elements or actors that are being judged. For instance, even though we have only limited understanding of chemical compounds and structures, we take drugs on a premise that drugs approved by the FDA are safe. For another instance, firms are interested in procuring the ISO (International Organization for Standardization) certification, because possession of the ISO certification signals firms' value and the quality of their manufacturing processes.

When infrastructures that disseminate reliable and credible information via authorities and mutual third parties are well developed, BD professionals are better able to conduct internal research and collect information on prospective partners without the help of the relational mechanism. Proliferation of such infrastructures is a

necessary condition for activation of the contextual mechanism because it is these infrastructures that endorse credibility and reliability for prospective partners and construct reputation as a crucial element of the contextual mechanism. In the biotechnology industry, there exist 3 major operators that contribute to development of the infrastructures: (1) the FDA, which approves pharmaceutical products\, (2) the USPTO (United States Patent and Trademark Office), which approves commercial patents of firms, and (3) academic journals, which approve scientific work of firms. Without these operators, it would be difficult for BD professionals to rely on prospective partners' reputation and credibility and activate the contextual mechanisms in reducing selection uncertainty and decreasing the role of the relational mechanism. Therefore, levels of both availability and credibility of information in the public domain, as environmental factors, influence ways in which BD professionals internally collect information on and conduct assessments of, prospective partners and patterns in which organizations use pre-existing rapport and activate the relational mechanism in forming alliances.

Relating to an issue of information in the public domain, the third factor is legal environment. Although it may be certain that well-developed information infrastructures in the biotechnology industry decrease the value of ties as an information source, one may claim that organizations are still unable to procure private information, so ties should remain valued as a source of private information (Uzzi, 1999). However, this is not the case in the biotechnology industry, where survival of firms is dependent upon private information and intellectual property. It is unusual for scientists to exchange private information without signing nondisclosure / confidentiality and disclosure agreements (NDA / CDA). It does not matter in

exchanging private information whether there is pre-existing personal rapport between firms because, regardless of its existence, firms do not exchange private information until they sign NDA / CDA. When the legal environment protects intellectual property or trade secrets and renders values to private information, ties may not function as a source of private information. On the other hand, in industries where exchange of private information across organizational boundaries may not be detrimental to organizational competitive advantage and where the legal environment has not provided a clear definition of private information, ties may be useful for procuring private information and reducing selection uncertainty.

The fourth factor is industrial associations. It is known that industrial associations disseminate information useful for building bridges between organizations and blurring organizational boundaries (Staber, 1985). Most biotechnology industrial associations are indeed interested in facilitating and helping partnerships and alliances by planning and sponsoring a number of scientific, business development, and investment meetings. Strangers from two different organizations are able to initiate new personal relations from such conferences that can trigger new partnerships and new alliances (Nohria, 1992). When industrial associations are active in facilitating partnerships and organizations use such opportunities in finding prospective partners, the value of ties and long-term personal rapport as seeds of new alliances may decrease.

The last factor is, as suggested in the institutional-theory argument, cognitive systems that specify how things should be done and define appropriate and legitimate means and conducts in pursuing goals and objectives (DiMaggio & Powell, 1983; Meyer & Rowan, 1977; Scott, 1995). In this research context, it is manifestly

pertinent to an issue of selection uncertainty about contribution, as well as trust or malfeasance and opportunism (Baradach & Eccles, 1989; Powell, 1990; Saxenian, 1994; Zucker, 1986). Trust is defined as "a type of expectation that alleviates the fear that one's exchange partner will act opportunistically" (Baradach & Eccles, 1989: 104). Opportunism refers to "a lack of candor or honesty in transactions, to include self-interest seeking with guile" (Williamson, 1975: 9). Actors in the biotechnology industry could behave opportunistically on the grounds that actors seeking certain technologies outside organizational boundaries should be dependent on specific others that possess and monopolize unique knowledge and technologies (Pfeffer & Salancik, 1978; Williamson, 1975). However, the fieldwork revealed that people I interviewed do not pay much attention to partners' possible malfeasance and opportunism. Although this may not necessarily mean that all actors in the biotechnology industry are trustworthy and honest, so there exist no interpersonal conflicts in alliances and interorganizational conflicts between allying firms, what I have observed is, at least, that interviewees I met did not stress the issue of trust and opportunism as much as do transaction cost economists (Williamson, 1975, 1981, 1985). There should be an industry-level culture and norms that shape actors' behavior and discourage opportunism and malfeasance in alliances. This macro-level control mechanism replaces repeated direct interactions and shared experience in generating trust between organizations, so pre-existing personal rapport is devalued in reducing selection uncertainty about contribution (Zucker, 1986; Saxenian, 1994).

One of the origins of this macro-level control mechanism is that most of the actors in the biotechnology industry hold doctoral degrees in biochemistry, chemistry, biology, or medicine. Their education and professional training should generate a

culture and norms that discourage malfeasance and opportunistic behavior (i.e., respect for intellectual ownership of others' work).

Another origin is the relatively small size of the industry. Although there are about 350 publicly-held biotechnology firms in the United States, the whole industry can be scaled down into some fundamental technologies (e.g., screening and small molecular modification) or some therapeutic fields (e.g., cancer and AIDS). In such small business communities, bad reputation travels quickly by word of mouth, so this threat discourages actors from behaving opportunistically. The macro-level control mechanism increases confidence in trustworthiness of organizations and, hence, reduces the role of pre-existing rapport and the relational mechanism that also help organizations reduce selection uncertainty about contribution.

As noted above, the model of virtualization will not be completed until we collect data for testing these intraorganizational and environmental factors that have been excluded from this research. A contribution of this research regarding this model is limited to a finding on the circulation processes by which alliance experience and collaborative know-how change patterns of alliance formation and selection of alliance partners.

9-5: Conclusions

This research began by asking how organizations reduce uncertainty in selecting R&D alliance partners. This first question is important and interesting because (1) a number of firms form alliances and construct interorganizational networks in pursuing their goals and (2) while previous research claimed a close linkage between selection uncertainty, complementarity in alliances, and effectiveness of alliances, little has been known about how organizations identify prospective

partners, select appropriate partners, and form alliances and what mechanism enables organizations to reduce selection uncertainty.

Results from the fieldwork, as well as the literature review, uncovered 3 uncertainty mechanisms for reducing selection uncertainty: (1) the relational, (2) the internal, and (3) the contextual mechanism. The relational mechanism is the means by which organizations employ cultivated pre-existing and ongoing social ties in reducing selection uncertainty. The internal mechanisms are internal capabilities and structures that help organizations reduce selection uncertainty and that consist of collaborative know-how, boundary spanning, and technical intensity. The contextual mechanism means that prospective partners' reputations signal credibility and help the focal organization reduce selection uncertainty. Although organizations use time and resources prior to legal engagement in economic exchange so as to reduce selection uncertainty and ensure formation of high-performing alliances through these mechanisms, I also found that bounded rationality makes it impossible for organizations to predict every contingency and reduce selection uncertainty completely.

By using archival data, I then examined interrelatedness among the 3 different mechanisms. It is interesting and important to examine the interrelatedness, not only because it has been one of the core themes in organization research, but also because I was able to learn, by predicting usage and activation of the relational mechanism, how organizations change use of, or reliance on, prior connections in reducing selection uncertainty; how the role of such connections change in forming alliances; and, more generally, how organizations construct interorganizational networks. I obtained indirect and modest support for a hypothesis that the internal mechanisms,

collaborative know-how and boundary spanning, increase internal capabilities to reduce selection uncertainty and decrease reliance on the relational mechanism. In addition, I found that as organizations develop collaborative know-how, they reduce reliance on the contextual mechanism. It was also found that pre-existing connections and internal investment in technological capabilities are helpful in gaining access to organizations with higher status.

Finally, by using data from mail surveys, I examined associations between the relational mechanism and alliance performance. Although it is believed that using social ties is useful for executing economic transactions (Gulati, 1997; Larson, 1992; Uzzi, 1996, 1999), I found that there exist no direct and obvious associations between them. Instead, I found that there are some moderators that transform the presence of ties into something that is valuable for resolving problems during the course of collaboration. For instance, as organizations develop collaborative know-how as a result of accumulating alliance experience, they become able to use pre-existing personal rapport purposefully and wisely for achieving goals of alliances.

Appendix 3-1: Samples in the Fieldwork

	Firm Status	*Interviewees at Firm*	*Firm's Major Business Field*	*Approximate Number of Employees*
1	Public	Director of Business Development (BD)	Chemical libraries	600
2	Public	Vice President of BD	Oncology	200
3	Public	CEO	Complex carbohydrates	50
4	Industrial Association	Director and Associate of Technology Development		20
5	Public	Senior Director of BD	Molecular immunology	50
6	Public	Senior Vice President of BD	Cancer products	3500
7	Public	Senior Vice President of Finance and BD	Vascular imaging	100
8	Public	Senior Director of BD	Genetics, Genomics and Bioinformatics	700
9	Public	CEO	Cancer products	10
10	Public	Administrative Vice President	Oncology	100
11	Public	Senior Vice President and Senior Director of BD	Neurological Disorders	300
12	Public	Vice President of Finance and Administration	Molecular and cell biology	400
13	Private	President	AIDS products	10
14	Non-profit	Director of Business	Research consortium	10
15	Private	Senior Vice President of Business and Technology Development	Insulin	400
16	Private	President	Toxicology, microbiology and analytical chemistry	300
17	Public	Vice President of BD	Medicinal chemistry and organic synthesis	100
18	Private	Regional Manager	Food science	10
19	Private	President	Food science	15
20	Private	President	Recombinant proteins	10

Appendix 3-2: A Sample Letter

[DATE]

[Mr./Ms./Dr.] [FIRST AND LAST NAME]
[TITLE]
[COMPANY]
[ADDRESS]
[CITY], [STATE] [ZIP CODE]

Dear [Mr./Ms./Dr.] [Last Name]:

I am working on my dissertation at Cornell University. The research examines the formation of alliances. I am writing to you, because, if your time permits, I would be interested in speaking with you to learn about your experience with alliance formation. I obtained your contact and company information from the Recombinant Capital's web site.

My specific area of research is how biotechnologynology firms form R&D alliances, how biotechnologynology firms use personal networks as foundations of R&D alliances, and how social connections can be described between persons who became involved in alliance formations. I am particularly interested in the following alliances you recently formed.

[NAME OF ALLIANCES]

The interview would take 50-70 minutes. The results of my research project, should you decide to participate, would be made available to you. The information you provide in the interview would be held strictly confidential. None of your individual responses will ever be seen by anyone other than me. Further, neither your name nor the company's name would ever be mentioned or associated with the information you provide.

Your participation in this study is very important, because it is the only way I can examine how alliances emerge and what causes changes in patterns of alliance formations.

I will call you next week to arrange a convenient time when we might be able to speak. If you wish to contact me, I can be reached by e-mail at hm18@cornell.edu or by phone at 607-255-7622 (office) or 607-266-0435 (home).

Thank you for your time and consideration. I look forward to speaking with you.

Sincerely yours,

Hitoshi Mitsuhashi
Ph.D. Candidate
Cornell University
NY State School of Industrial and Labor Relations
Department of Organizational Behavior

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Ithaca, NY 14853-3901
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Fax: 607-255-8484
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http://www.people.cornell.edu/pages/hm18

Appendix 5-1: List of the Large Pharmaceutical Firms in the Data Set

1. 3M
2. Abbott Laboratories
3. Allergan
4. American Home Products
5. Amgen
6. Bristol-Myers Squibb
7. Dupont
8. Eli Lilly
9. Hoffman-La Roche
10. Johnson & Johnson
11. Merck & Co.
12. Monsanto
13. Pfizer
14. Pharmacia & Upjohn
15. Procter & Gamble
16. Schering-Plough
17. SmithKline Beecham
18. Warner-Lambert

Appendix 6-1: Results of x^2 Tests[1]

	Direct interlocking	*Indirect interlocking*	*Repeated ties*	*Investor ties*	*CEO social similarity*
R&D experience	1.8816 (.170)	2.1307 (.144)	4.8601 (.027)	.2658 (.606)	.0410 (.839)
IOR experience	2.4095 (.121)	.1469 (.702)	2.2662 (.132)	.7107 (.399)	.3683 (.544)
Organizational age	2314 (.631)	.6549 (.418)	.8152 (.367)	.0698 (.792)	2.0020 (.157)

Note 1: x^2 values and p-values in parentheses
Note 2: The cell for the combination of *Direct interlocking* and *R&D experience* contains results of the x^2 test for the frequency table of these two variables.

Appendix 7-1: The Cover Letter for the Questionnaire Surveys

February 14, 2000

Name
Company name
Street address
City, State, and Zip Code

Dear Name

My name is Hitoshi Mitsuhashi, and I am currently working on my Ph.D. dissertation at Cornell University. I am writing to request your participation in a brief survey concerning the determinants of successful R&D partnerships in the biotechnology industry. In exchange of your participation, I will send you a copy of the final report. This is an extremely important topic, because R&D partnerships frequently determine growth and success of organizations. I am particularly interested in how partnership formation processes and business development activities influence performance of partnerships.

Your participation is extremely important because it is the only way to examine complex relationships between efforts in partnership formation processes and successful partnerships. This survey will take about 7-10 minutes to complete.

Your participation is strictly voluntary. Your answers are strictly confidential.

No one will have access to the surveys or any data that would allow identification of your answers. The surveys will be kept at Cornell in a locked office. Your answers will be combined with answers from other employees for statistical analysis only.

If you are not responsible for business development, please pass this survey to the head of your firm's business development group.

The following instruction pertains to the enclosed survey.

1. In this packet, you should have received the following materials:
   - 1 cover sheet (this letter);
   - 1 **gray** + 1 **yellow** question sheets for you or the head of your firm's business development group;
   - 2 **yellow** question sheets for you or your business development professionals;
   - 3 pre-addressed, stamped envelopes for return mail.
2. The **gray** question sheet contains **general questions** about your business development units and activities. I would like **you (or the head of the business development group)** to complete the gray sheet.

3. The **yellow** sheets ask you to consider **three R&D joint ventures or strategic alliances formed by your firm between 1995 and 1999 in which you conducted assessments of partners in the alliance formation process**. New R&D partnerships here mean that your firm had never formed partnerships with the firms before (not repeated partners).
4. If you are familiar with the three partnership cases you choose at Step 3, please complete the three yellow sheets.
5. If you are not familiar with all of the three partnership cases you choose at Step 3, please pass the yellow sheets to your business development members or other organizational members who are most familiar with the partnerships.
6. The **yellow** sheets contain "**case-study**" questions regarding the joint ventures or strategic alliances you chose. Each yellow sheet contains identical questions. Therefore, **please use one yellow sheet per joint venture or strategic alliance.**
7. After completing the questionnaires, please use the enclosed envelopes for return-mail. I enclosed 3 pre-addressed, stamped envelopes for your convenience.

If you have any questions concerning the study in general or any of the survey items in particular, I can be reached by e-mail at **hm18@cornell.edu** or by phone at **607-255-7622**. You can also contact my advisor, Professor Robert N. Stern, at **rns1@cornell.edu** or **607-255-3048**.

Thank you very much for your assistance.

Sincerely yours,

Hitoshi Mitsuhashi
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Appendix 7-2: The Following-up Card

My name is Hitoshi Mitsuhashi, and I am currently working on my Ph.D. dissertation at Cornell University. Last month, I send you a survey packet and asked your assistance for my dissertation project about the *determinants of successful R&D partnerships in the biotechnology industry.*

If you have returned the survey sheets to me, I would like to thank you very much. I will send you a copy of the final report as soon as possible.

If you have not returned the survey sheets to me, I would like to ask you to consider your participation again. Your participation is extremely important, because there is no other way to collect data for understanding complex relationships between business development activities and alliance performance. Your answers are strictly confidential and will be combined with answers from other organizations for statistical analysis only. Please let me know if you have any questions or if you need another packet by e-mail at hm18@cornell.edu or by phone at 607-255-7622. You can also contact my adviser, Robert N. Stern, at rns1@cornell.edu or 607-255-3048.

Hitoshi Mitsuhashi, Ph.D. Candidate
Cornell University, New York State School of Industrial and Labor Relations

Appendix 7-3: The Survey Sheet

THE GRAY SHEET (GENERAL QUESTIONS)

Hitoshi Mitsuhashi
Cornell University (hm18@cornell.edu / 607-255-7622)

The company name shown above is for **administrative purposes only**. Your individual and company names will never be revealed in the final output.

Q1: How many years of experience do you have as a business development (BD) professional?

Approximately ( ) years.

Q2: How has the number of BD professionals in your firm changed since 1995? What proportions of the BD professionals have a Ph.D. degree in biotechnology-related fields?

Year	The number of BD professionals	% of Ph.D. holders
1995		
1996		
1997		
1998		
1999		

Q3: Please think about how often your scientists and BD professionals go to scientific, BD, or investment meetings, or visit other firms to exchange information. In the box below, for each group please enter the number.

1: Never
2: Once a year or less
3: Once every 6 months
4: Every other month
5: Once a month
6: More than once a month

	Scientists	BD Persons
Scientific meetings:		
BD meetings:		
Investment meetings:		
Other firms:		

Q4: On average, what percentage of your alliances is formed out of "cold calls"?

( ) %

Q5: Do you have any written check / question list for the due diligence process?

1: No, we do not have any written checking list.
2: Yes, we do have the written checking list.
⇒ If "Yes", when did the firm make the list first?
We made the list first in (_____) (year).

Q6: How often does your BD group use the following databases to identify and research prospective partners? Please choose and fill in the correct number in the table below.

1: Never *4: Often*
2: Seldom *5: Always*
3: Sometimes

Database		Your Answer
1.:	Bioscan	
2.:	Widhover's Strategic Intelligence Systems (SIS)	
3.:	Pharma Projects	
4.:	R&D Focus	
5.	BioWorld	
6	BioCentury	
7:	Pharmaceutical Executive	
8	SEC filing database (i.e. Edgar, Lexis/Nexis etc.)	
9	Prospective partners' web sites	
10	Other (Specify:)	

Q7: Please state how much you agree or disagree with each of the following statements, using the numbers from the scale.

	Strongly Disagree ◄——► Strongly Agree				
1: Members of our top management team have common ideas about how partners should be selected.	1	2	3	4	5
2: Members of our top management team have common ideas about what factors lead to successful partnership.	1	2	3	4	5
3: I have an established idea about how partners should be selected.	1	2	3	4	5
4: I have an established idea about what factors lead to successful partnership.	1	2	3	4	5

Thank you very much for your assistance.

THE YELLOW SHEET (CASE STUDY QUESTIONS)

Hitoshi Mitsuhashi
Cornell University (hm18@cornell.edu / 607-255-7622)

I appreciate your participation in this important study to examine how partnership formation processes influence performance of partnerships.

Your participation is extremely important because it is the only way to examine complex relationships between efforts in partnership formation processes and successful partnerships. This survey will take about 4 - 7 minutes to complete.

Your participation is strictly voluntary. Your answers are strictly confidential.

The company name shown above is for **administrative purposes only**. No one will have access to the surveys or any data that would allow identification of your answers. The surveys will be kept at Cornell in a locked office. Your answers will be combined with answers from other organizations for statistical analysis only.

Q1: Please provide **the name of a partnering firm** you are considering in answering questions on this sheet. The information you provide here will be held **strictly confidential**.

Name of the partnering firm (**)**

Q2: When did the partnership start?

Month / Year (**/** **)**

Q3: What is the structure of alliances? Please circle one.

1. **Joint venture** (partners create a separate entity in which each owns a portion of the equity)
2. **Minority investment** (one partner takes a minority equity position in the other).
3. **Collaborative alliance** (partners work equally without creating a new organizational entity and sharing or exchanging equity).
4. **Contractual alliance** (one of the firms outsources its research projects to the other with some payments).

Q4: Did your firm make the initial contact to start the discussion about the possibility of partnership? Please circle one.

1: **Yes**. We contacted them.
2: **No**. They contacted us.

Q5: What was **the stage of project or product** at the outset of the partnership? Please circle one.

1. Synthesis and Extraction
2. Biological Screening and Pharmacological Testing
3. Pre-clinical Studies (Toxiology and Safety Testing and Pharmaceutical Dosage Formulation and Stability)
4. Clinical Studies Phase I
5. Clinical Studies Phase II
6. Clinical Studies Phase III

Q6: Please circle the number of the **contact person** in your firm and the partnering firm. "**Contact persons**" are those who played the most influential role in initiating the partnership formation process. There might be multiple pre-existing connections with the partnering firm. In that case, please consider the most influential pre-existing connection. Please circle the correct number in the list below.

Your Firm
1: Board Member
2: CEO
3 CSO or Senior Scientist
4: Business Development Professional
5: Scientist
6: Other ( )

Your Partner
1: Board Member
2: CEO
3: CSO or Senior Scientist
4: Business Development Professional
5: Scientist
6: Other ( )

Q7: Please circle the item that best describes **the relationship between the contact persons** prior to the initial contact to discuss the possibility of partnership? Please circle one.

1. Stranger.
2. Acquaintance.
3. Good friend.
4. Very closer friend.

Q8: About how long did the contact persons know each other prior to the initial contact to discuss the possibility of partnership? Please circle one.

1. Had never met.
2. Less than a month
3. Less than a year
4. 1 – 3 years.
5. 3 – 10 years.
6. More than 10 years.

Q9: On average, how often did the contact persons communicate with each other prior to the initial contact to discuss the possibility of partnership? Please circle one.

1. Never.
2. Once a year or less.
3. Once every 6 months.
4. Once every 3 months.
5. Once a month.
6. Once a week.
7. More than once a week.

Q10: How did the contact persons meet each other originally? Please circle one.

10. One of them found the other's name in a directory or database.
11. They used to work in the same company.
12. They met in a workshop or conference.
13. They went to the same school or university.
14. A venture capitalist introduced them.
15. Someone, other than venture capitalists, introduced them.
16. One of them sat on the board of the other's firm.
17. Both are committee members of other firms or other organizations (i.e. industrial associations).
18. They met when one of them visited the other's firm during her/his business trip.
19. Other (Please specify:)

Q11: Think of the names of five close business friends of the contact person in your firm. How many of them were also friends of the contact person in the partnering firm prior to the initial contact to discuss the possibility of partnership? Please circle one.

1. 0
2. 1 person
3. 2 persons
4. 3 persons
5. 4 persons
6. 5 persons

Q12: Think of the most **outstanding scientists** in your and the partnering firms who have expertise in the fields relevant to the partnership. How many scientific papers did they publish in the period between the year of the alliance formation and three years prior? Please circle one.

The Most Outstanding Scientist **in Your Firm**	The Most Outstanding Scientist **in the Partnering Firm**
1. Zero. 2. 1 – 3 publications 3. 4 – 6 publications 4. 7 – 10 publications 5. 10 – 15 publications 6. More than 15 publications	1. Zero. 2. 1 – 3 publications 3. 4 – 6 publications 4. 7 – 10 publications 5. 10 – 15 publications 6. More than 15 publications

Q13. Please state how much you agree or disagree with each of the following statements, using the numbers from the scale. Please circle one.

	Strongly Disagree ◄——► Strongly Agree						
1: The partner firm carried out the commitments it initially agreed to in regard to my firm.	1	2	3	4	5	6	7
2: I feel that the partnership was scientifically successful.	1	2	3	4	5	6	7
3: I feel that the partnership was commercially successful.	1	2	3	4	5	6	7
4: The time and effort spent in developing and maintaining the relationships with my partner were worthwhile.	1	2	3	4	5	6	7
5: Overall, I am satisfied with the relationship between my firm and the partner.	1	2	3	4	5	6	7

Thank you very much for your assistance.
If you have any question about this research, please contact me at 607-255-7622 or hm18@cornell.edu. You can also contact my advisor, Professor Robert N. Stern, at 607-255-3048 or rns1@cornell.edu.

Appendix 7-4: Logistic Regression for Checking the Sample Bias[1]

	Odds Ratio	Std. Err.	Significance
ROI^2	1.0009	.0023	
ROE	.9992	.0016	
ROA	1.0083	.0071	
R&D expenditures	1.0099	.0133	
Net income	.9905	.0090	
Assets	.9984	.0025	
Calendar-year-end stock price	.9630	.0332	
x^2	.6406		
Log likelihood	-64.8003		
Pseudo R^2	.0383		

Note 1: The dependent variable: whether a firm participated in the survey (1 = yes, 0 = no)
Note 2: All data are obtained from 1998 Compustat.

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