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Finding a Partner: Selection Uncertainty in Alliance Formation

by

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ABSTRACT

This research examines how organizations reduce uncertainty that they face when forming alliances and (2) how the uncertainty reduction mechanisms are related to each other. While previous research has reached consensus that selection of appropriate partners is one of the crucial determinants for successful alliances, our knowledge is limited to a claim from the embeddedness approach that firms use a history of interactions for this selection uncertainty. By conducing fieldwork at the 22 U.S. biopharmaceutical organizations, we identified three mechanisms for reducing selection uncertainty: the (1) relational, (2) internal, and (3) contextual mechanisms. In addition, by using various archival data about biopharmaceutical R&D alliances, we found that (1) firms with higher internal information processing capabilities for finding alliance partners are more likely to form alliances with which they have a history of fewer interactions, and (2) firms are better able to form alliances with prominent firms when they have a history of interactions. The former finding suggests the role of organizational structures and capabilities in changing patterns of interorganizational networks. The latter finding implies an instrumental value of embedded ties for removing status distance in constructing interorganizational networks.

INTRODUCTION

The purposes of this research are to examine (1) how organizations eliminate uncertainty that they face when forming alliances and (2) how the uncertainty reduction mechanisms are interrelated to each other. These research questions are interesting and important for the following reasons.

First, this research addresses a question about selection uncertainty in alliance formation. An alliance is defined as "a novel form of voluntary cooperation that involves significant exchange, sharing, or codevelopment and thus results in some forms of enduring commitment between the partners" (Gulati & Gargiulo, 1999: 140). It can also be defined simply as "contractual asset pooling or resource exchange agreements between firms" (Stuart, 1998: 668).

There is little doubt that American firms have been increasingly forming R&D (research and development) alliances as part of their business strategy (Gomes-Casseres, 1996; Kanter, 1989). In general, previous research reported that firms form alliances 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 exceeds affordability of a single firm, (4) managing interdependence, (5) sharing strategic information with competitors (Kogut, 1988; Oliver, 1990; Powell, 1990).

Previous research has also reached a consensus that one of the crucial determinants for effective alliances is elimination of uncertainty that organizations face in selecting alliance partners, which we term selection uncertainty (Doz & Hamel, 1998). Selection uncertainty describes a situation in which organizations do not know a priori which prospective partners will best serve their interests (Gulati & Gargiulo, 1999). Two types of selection uncertainty are uncertainty about (1) technological competence and (2) behavior (Geringer, 1991; Sober & Schrader, 1998). On the one hand, the former refers to ambiguity about whether or not prospective partners have technological competence and resources required for achieving goals of proposed alliances. Firms face this type of selection uncertainty because (1) scientific knowledge and technical know-how are not always explicit, but tacit (Collins, 1985; Nelson &

Winter, 1982) and (2) as described as "adverse selection" in agency theory literature, prospective partners may misrepresent their capabilities to establish proposed exchange relations (Eisenhardt, 1989a: 61). On the other hand, the latter refers to ambiguity about behavioral aspects of prospective partners. Differences of organizational culture (Doz & Hamel, 1998) and possible malfeasance and opportunistic behavior of prospective partners (Eisenhardt, 1989a; Williamson, 1975) create uncertainty regarding whether or not prospective partners are reliable and trustful as collaboration partners.

Elimination of selection uncertainty is important because it determines (1) organizational accessibility to resources and technology in the environment and (2) complementarity and the win-win situations in which partnering firms combine their own strength to overcome the weakness (Doz & Hamel, 1998; Gulati & Gargiulo, 1999). Regardless of this consensus, however, work on selection uncertainty is still in its infancy. This research is going to make contributions to alliance research by examining selection uncertainty and, particularly, mechanisms that organizations use for reducing selection uncertainty.

Second, this research is going to contribute to the embeddedness approach by examining the role of a history of interactions in eliminating selection uncertainty and forming interorganizational networks. Embeddedness refers to "on-going contextualization of economic exchange in social structures" (Dacin, Ventresca, & Beal, 1999: 320). This approach asserts 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), and that "in ongoing relations, human beings do not start fresh each day, but carry the baggage of previous interactions into the new one" (Granovetter, 1990: 99).

Previous research taking the embeddedness approach (Granovetter, 1985) suggests that firms reduce selection uncertainty by forming alliances upon pre-existing personal and organizational ties because a history of interactions is a conduit of technological information and generates norms of reciprocity between partnering firms (Eisenhardt & Schoonhover, 1996; Gulati & Gargiulo, 1999; Larson, 1992; Ring & Van de Ven, 1993). A history of interactions

therefore helps organizations ensure whether or not prospective partners have technological competence required for achieving goals of collaborative projects as well as whether or not prospective partners are reliable and trustful.

Regardless of the importance of a history of interactions in constructing interorganizational networks, it is not reasonable to suppose that all of alliances emerge out of embedded ties. Indeed, the most recent effort in the embedded approach views embeddedness not only as an academic program but also as a variable (Block, 1990; DiMaggio & Louch, 1998; Granovetter, 1995; Uzzi, 1996, 1999). DiMaggio and Louch (1998), for instance, found that while it is certain that people use personal ties for purchasing goods and services, their use of the ties varies with types and characteristics of transactions as well as their individual attributes. Given that there exist variations in organizational use of a history of interactions in reducing selection uncertainty and forming alliances, what accounts for the variations? This research is going to make contributions to the embeddedness approach by examining factors that account for organizational use of a history of interactions in forming alliances.

The overall purposes of this research are to examine mechanisms for reducing selection uncertainty and account for variations in organizational embeddedness. In order to achieve these objectives, we strength our analysis using a triangulation of theory, fieldwork, and statistical analysis (Jick, 1979). This research views a history of interactions as a mechanism for reducing selection uncertainty and proposes that alternative mechanisms that substitute or replace its role change organizational reliance upon it in constructing interorganizational networks. By conducting fieldwork at 22 biopharmaceutical organizations, we unfolded alliance formation processes and identified the internal and contextual mechanisms as the alternative mechanisms for reducing selection uncertainty. While the former operates on the principle that internal capabilities and structures of organizations reduce selection uncertainty, the latter operates on the principle that reputations of prospective partners reduce selection uncertainty. After substantiating our claim by using results of questionnaire surveys that there exist variations in organizational embeddedness in constructing interorganizational networks, we

hypothesized that the relational mechanisms is negatively associated with the internal and contextual mechanisms because firms are able to increase reachability to technology and resources outside organizational boundaries by reducing the role of embedded ties in constructing interorganizational networks. By using biopharmaceutical R&D alliances data from various archival sources, we tested hypotheses and found that information-processing capabilities of firms for reducing selection uncertainty decrease their reliance on a history of interactions, implying that firms with the higher capabilities are more likely to disembed their interorganizational networks and decouple economic transactions from pre-existing and ongoing relations. We also found an instrumental value of embedded ties: a history of interactions enables firms to resolve the status distance and form R&D alliances with prominent firms.

This research demonstrates that internal structures and capabilities of firms influence their interorganizational phenomenon and increase their expandability of interorganizational networks by decreasing the role of a history of interactions. Development of organizational know-how, and dedication of resources, for selecting alliance partners make interorganizational networks of firms less path-dependent and more disembedded. The internal elements of organizations shape patterns regarding with whom firms form alliances and how they evolve the interorganizational networks.

THE RELATIONAL MECHANISMS AND ITS VARIATIONS

Fieldwork

We conducted fieldwork at 22 biopharmaceutical organizations for unfolding alliance formation processes, understanding organizational activities prior to alliance formation, and identifying mechanisms that organizations use for reducing selection uncertainty. Fieldwork is appropriate because previous research (e.x., Inkpen & Dinur, 1998; Lorenzoni & Lipparini, 1999) placed more focus upon ways by which firms manage alliances and run collaborative projects after alliance formation and therefore restricted our understanding about what firms do prior to alliance formation (Gulati & Gargiulo, 1999; Stuart, 1998).

Biopharmaceutical R&D alliances are appropriate subjects for our purposes. A number

of previous studies reported that the biopharmaceutical industry is known as a research- and knowledge-intensive industry, where procurement of and access to cutting-edge knowledge and technologies through alliance formation are crucial for growth and survival of the firms (e.x., Barley, Freeman & Hybels, 1992; Ryan, Freeman, & Hybels, 1995). In addition, the large amount of financial investment and long-term commitment required for drug discovery activities manifest the importance of selection uncertainty in forming biopharmaceutical R&D alliances (Pharmaceutical Research and Manufacturers of America, 2000; Standard & Poor's 1995, 1998).

We used *Recombinant Capital Biotechnology Alliance Database* and *Windhover's Healthcare Strategists* and identified 65 publicly-held firms locating at the northeastern part of the United States. We used *Corporate Directory of Technology Companies* and identified 40 privately-owned firms in the central New York area. We sent letters to presidents, CEOs (chief executive officers), or BD (business development) executives of the firms and followed up the letters after a week with phone to make appointments. The participation rates in this fieldwork were approximately 20 % (22 out of 105).

All of 22 organizations are located on the northeast of the United States. Of the 20 biopharmaceutical firms, 12 (63%) were publicly held. The number of their employees varies from 5 to 3500. Business domains of the commercial firms cover various therapeutic (i.e., HIV, cancer, and diabetes) and technological fields (i.e., oncology, complex carbohydrates, molecular immunology, and bioinformatics). Three of the privately-owned firms make more profit from bio-nutrition and food science than from biopharmaceutical business. The two non-profit organizations are funded by local state governments: (1) a state-level industrial association and (2) a research organization that creates research consortiums and facilitates collaboration among firms, universities, research institutions, and hospitals in the area.

We conducted on-site interviews with an exception of a phone interview. The average interview time was approximately 80 minutes. Sixteen of the 22 interviewees have doctoral degrees in biology, chemistry, biochemistry, or medicine. Six of the interviewees in the commercial firms were either presidents or CEOs of the firms. The rest of the 14 interviewees

in the commercial firms were BD executives, directors, or professionals. Two of the interviewees in the non-profit organizations were directors of BD or technology development. We used tape recorders at the 13 sites upon permission from the interviewees.

Alliance Formation Processes

Almost all of the alliance formation processes we learned in the fieldwork consist of the following five phases, though the intensity of work and the amounts of resources used in each phase vary with firms as well as alliances: (1) defining alliance opportunities, (2) identifying sets of prospective partners, (3) making contacts, (4) proceeding due diligence processes, and (5) making deals. Two remarks should be noted here. First, we only provide brief descriptions of alliance formation processes here to avoid redundancy with the following arguments. Second, firms have both proactive and passive approaches in finding alliance partners. The passive approach operates on the principle that other organizations (e.x., other biopharmaceutical firms, consulting firms, venture capitalists, and industrial associations) approach the focal firms and propose them alliance opportunities. The proactive approach, on the other hand, operates on the principle that "the company systematically uses alliances and collaboration in order to achieve the strategic goals" (a comment by a BD director). We focus upon the proactive approach in this discussion, which will provide us more fruitful opportunities to understand organizational efforts to reduce selection uncertainty.

Alliance formation processes begin with defining potential alliance opportunities and determining prerequisites for technological competence of prospective partners on the basis of their own business strategies, current technological strength, and business domains in the life-cycles of drug-discovery processes. For instance, when a firm attempted to form alliances to enter into the diabetes market with the application of its small molecular technology, the technological prerequisite for the proposed alliance is an expertise in the biological mechanisms of diabetes.

After identifying sets of prospective partners and making contacts, firms and their prospective partners engage in scientific due diligence processes, in which they (1) exchange

confidential information upon signing the non-disclosure agreements, (2) have scientific meetings to assess technological competence of each other, (3) conduct internal research and have business meetings to assess and ensure potential commercial values of proposing alliances, and (4) negotiate terms.

One of the firms we visited completed a 10-month due diligence process with a large pharmaceutical firm. The large pharmaceutical firm looked for prospective partners to which it could outsource its research program for discovering efficient processes for extracting complex chemical compounds out of natural resources and engaged in due diligence processes with this biopharmaceutical firm for ensuring its technological competence. A joke made by the CEO portrayed an essence of due diligence processes:

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

His comments picture one of the organizational efforts for reducing selection uncertainty. Scientific due diligence processes are followed by business due diligence processes if prospective partners are considered to be competent technologically. Actors involved in this second part of the due diligence processes include (1) attorneys for the intellectual property issues, (2) finance and marketing professionals for conducting cost-benefit analyses and estimating potential market size of proposing projects, (3) manufacturing experts if proposing alliances involve manufacturing, (4) clinical trial experts and medical doctors for examining potential medical applications of proposing projects, (5) experts for the health-insurance issues, and (6) BD professionals for coordinating all of the due diligence activities and conducting further internal research about prospective partners and proposing projects.

It is evident that firms make a lot of efforts for, and invest a large amount of resources in, assessing the technological facet of prospective partners and ensuring potential commercial

values of proposed alliances. Moreover, due diligence processes require interactions and information exchange between scientists and business professionals across organizational boundaries, so firms are able to assess the behavioral facet of prospective partners. One of the BD directors commented that:

> Different people and different organizations have different styles and cultures. Sometimes these 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?

One of the uncertainty reduction mechanisms that firms use along with these processes is the relational mechanism. In what follows, we are going to provide details of this mechanism with an emphasis on our finding that there exist variations in organizational use of the relational mechanism, which substantiate the claim that there are variations in organizational embeddedness in constructing interorganizational networks.

The Relational Mechanism

The relational mechanism operates on the principle that firms use prior organizational ties and cultivated personal rapport for reducing selection uncertainty. A number of efforts have been made to understand how social ties involving a history of interactions influence decision making in organizations and shape a variety of organizational actions (Kraatz, 1998; Myer, 1994; Pfeffer, 1981; Salancik & Pfeffer, 1978). The work taking the embeddedness approach (Granovetter, 1985) is central to such endeavor in the field of interorganizational relations research, which provides evidences that organizations use pre-existing organizational ties and cultivated personal rapport in collecting information about, and identifying, prospective partners. Individuals connected with each other are better able to communicate detailed, thick, timely, accurate, and reliable information, so ties and personal rapport are conduits for firms to collect information about technological facets of prospective partners (Aldrich & Herker, 1977; Edstrom & Galbraith, 1977). In addition, by forming alliances from cultivated personal rapport, firms

are able to transfer behavioral expectations at the individual levels to the organizational ones and hence avoid facing malfeasance and opportunistic behavior of partners (Larson, 1992; Uzzi, 1996).

Larson (1992) and Uzzi (1996) provided qualitative evidences that alliances between entrepreneurial firms arise from such personal rapport as friendship ties, neighborhood ties, and third-party referrals. Larson (1992: 84) claimed that "concrete personal relations provided a conductive frame for economic exchange." In addition, Eisenhardt and Schoonhover (1996), Gulait and Gargiulo (1999), Gulati and Westphal (1999), and Podolny (1994) found that organizations use pre-existing social contacts and organizational ties in finding alliance partners because a history of interactions increases familiarity, generates the behavioral norms, and reduce selection uncertainty.

Our interviewees in the fieldwork agreed with this instrumental value of embedded ties. The director of the non-profit organization, for instance, gave us an interesting example in which the lay-off of scientists from a German pharmaceutical firm created dispersed social networks across organizational boundaries in the region, so many of the firms are able to start collaborative projects out of the collegial networks. It was also found that some of the alliances originated from directorate ties and friendship between CEOs who graduated from the same graduate school.

However, it should not be overlooked that our interviewees did not consider pre-existing ties to be a crucial determinant of alliance formation. A BD director commented that:

> I think social networks are important to make an initial contact. I think social networks do not really matter much in due diligence processes. If our scientists respect their scientists highly scientifically or when they might think them to be credible, it does matter. But it is not a social network. The issue is scientific credibility. That is different from social networks.

A CEO commented that:

> Friendship often mediates the difficulties (in making contact) prior to the CDAs (confidential / disclosure agreements). I've never seen the business relationships after the CDAs on the basis of the friendship. I think the fact is a lot of people have a lot to

> talk about and a lot of rooms for mutual profit if you get together. So, I think the social relationships facilitate the contact phone calls. I've never seen the business deal gets made because two people are friends.

Despite the agreements among the interviewees that pre-existing ties and personal rapport are useful and helpful for forming alliances, they do not seem to be a necessary condition for the subject firms to build alliance networks. One of the possible reasons, according to one of the interviewees, is that biopharmaceutical is not a commodity industry, so firms sometimes need to approach other firms to gain access to their unique technology even though there is no pre-existing connection. The strong orientations for technology make the role of embedded ties be marginal or supplemental (Granovetter, 1990).

Another possible reason is a specific characteristics and context of the biopharmaceutical industry. One of the interviewees commented that:

> In general, we work in a very competent industry (in terms of behavior and conducts). Those who are not competent do not survive. So, the general assumption about most companies' capabilities is that caliber people have is reasonably high. Typically, biotech companies were formed around Ph.D.s. ... In this business which is relatively a small industry, you get a pretty quick reputation. It is hard to survive without being good.

While Larson (1992) and Uzzi (1996) pointed out the importance of embedded ties in avoiding malfeasance and opportunistic behavior of partners, the above comments demonstrate that the intrinsic characteristics of this industry offers a so-to-speak macro system that controls the possible malfeasance, so the value of embedded ties in reducing this facet of selection uncertainty is discounted (Zucker, 1986).

Because pre-existing ties are not a necessary determinant for alliance formation for these two reasons, there are variations in types of ties used in forming alliances. Alliances sometimes emerge out of circumstantial ties generated from particular opportunities for creating and developing new inter-personal ties. Examples of such opportunities are (1) business and

scientific conferences, (2) company-sponsored research workshops[1], and (3) third-party referrals. Although ties developed from these circumstances do not involve a long history of interactions and as strong empathy as do collegial ties, these opportunities provide individuals to get to know each other and start cultivating relationships that will ultimately lead them to form alliances.

Moreover, some alliances emerge out of cold calls. BD professionals (see below) conduct internal research about prospective partners, identify sets of them, find names and phone numbers of BD professionals at prospective partners, and make cold calls. One of the BD executives commented that:

> I do a lot of that (cold calls). You will be more often successful if you talk to people you know. But, it is surely much part of business to get on the phones. You have to do homework ahead of time. You have to understand who you are going to call, what the company does, and if the collaboration makes sense. But, yeah, I get on the phone.

In principle, BD professionals call totally strangers and propose alliances. It appears that BD professionals in making cold calls care more about whether or not their firms and the prospective partners are able to combine their own technological strength and overcome the weakness by forming alliances than whether or not there exist any personal rapport and social ties between them.

In order to confirm this observation about variations of ties used in forming alliances, we distributed mail-surveys to BD professionals and CEOs at 285 publicly-held biopharmaceutical firms in the United States and obtained 46 alliance data from 23 firms (see Appendix 1 for the details of methodology). The company-level response rate was approximately 8 %. In this survey, we asked the subjects how three of their recent new (non-repeated) R&D alliances were formed and what descriptions of relationships prior to alliance formation are between persons in their firms and the partnering firms who played the most influential role in initiating the alliance formation process.

As well as a question of how the two people got to know each other at the beginning, we

[1] Company-sponsored research workshops are those like "guest-speaker workshops" or "research workshops" in universities.

used the traditional measures of tie strength to describe their relationships, which is defined by Granovetter (1973: 1361) as "a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual codifying), and reciprocal services which characterize the tie". Both measures and results are shown in Table 1, which present two important findings. First, we found variations in tie strength and origins of relationships out of which alliances were formed.

TABLE 1 ABOUT HERE

As found in the fieldwork, firms do not always build interorganizational networks upon strong ties. For instance, while 13% of alliances emerged out of "good friend" relationships, 60% of them are built upon "stranger" relationships. Second, we also found that about 50 % of the subjects' alliances involve little shared history of previous interactions: (1) 60 % of their alliances were build upon "stranger" relationships, (2) 45% of their alliances involved no previous interaction, (3) 56 % of the two individuals had never met prior to alliance formation processes, (4) 64% of the two individuals had no mutual friend, (5) 27 % and 11 % of the two individuals' relationships started from business trips and conferences, respectively, and (6) 29 % of their alliances were built upon cold calls. Although we need to discount these findings because of the small number of observations, the combination of the fieldwork and the mail-survey data enables us to conclude that there are variations in organizational reliance upon, or use of, a history of interaction and embedded ties in forming alliances.

In accounting for the variations, we propose that when alternative mechanisms for reducing selection uncertainty are available, firms decrease reliance on, or use of, the relational mechanism and select partners with whom they have a history of fewer interactions. There are two theoretical foundations for this claim. First, it is generally found that various mechanisms for reducing uncertainty are interdependent, so one mechanism is often replaced with others, depending upon types and levels of uncertainty they face (Galbraith, 1973; Stinchcombe, 1990; Thompson, 1967).

The second theoretical foundation is a sociological argument on ties and information redundancy (Burt , 1992; Granovetter, 1973; Hanssen, 1999; Krachhardt, 1992). Previous research implies that when organizations use the relational mechanism and rely upon a history of interactions in forming alliances, they are able to conduct interorganizational exchange with less conflict because pre-existing familiarity and norms of reciprocity facilitate resource-exchange and knowledge-sharing processes (Larson, 1992; Uzzi, 1996; Womack, Jones, & Roos, 1990). It was found that that pre-existing ties between partnering firms increase effectiveness and efficiency of interorganizational exchange that involves more complex, tacit, and latent resources and information (e.g., scientific knowledge and technical know-how) (Hard, 1994; Hanssen, 1999; Kunkle, 1995). However, on the other hand, when firms are dependent on a history of interactions, they are less able to gain access to heterogeneous and non-redundant resources and knowledge (Gulati & Gargiulo, 1999). This is because actors who have long histories of interactions tend to have similar information sources and access to information flowing in more closed networks (Granovetter, 1973; Burt, 1992). This issue of information redundancy is detrimental for achieving complementarity and procuring resources and knowledge in other firms that the focal firms currently do not possess (Saxton, 1997). Although the relational mechanism enables them to reduce selection uncertainty, it restricts their accessibility and reachability to non-redundant and heterogeneous resources and knowledge.

We claim therefore that the alternative mechanisms will (1) alleviate the problems of selection uncertainty and information redundancy, (2) replace the role of the relational mechanism in forming alliances, and (3) enable firms to select partners with whom they have fewer pre-existing interactions. In the next section, we show results of our fieldwork about the alternative mechanisms and present hypotheses to predict organizational use of the relational mechanism.

ALTERNATIVE MECHANISMS FOR REDUCING SELECTION UNCERTAINTY

The Internal Mechanism

The internal mechanism operates on the principle that the internal capabilities and

structures of organizations reduce selection uncertainty. It consists of three components, including (1) collaborative know-how, (2) boundary-spanning, and (3) technical intensity.

The first component of the internal mechanism is collaborative know-how (Barkema et al., 1997; Halebian & Finkelstein, 1999; Hill & Hellriegel, 1994; Lorenzoni & Lipparini, 1999). It is defined as "organizational know-how that determines how effectively new collaborations are entered and managed" (Simonin, 1997: 1154). There are three agreements in previous research: (1) firms are able to learn how to select alliance partners and how to manage alliances by accumulating alliance experience (Barkema et al., 1997; Powell et al., 1996; Simonin, 1997), (2) the higher degree of collaborative know-how enables them to gain access to diverse resources and knowledge outside organizational boundaries (Powell et al., 1996), and (3) the higher degree of collaborative know-how positively relates to performance of alliances (Simonin, 1997). Simonin (1997: 167) who examined survey data from 151 firms concluded that "firms do learn from past collaboration by developing skills in identifying potential collaborators, negotiating the form and specifics of collaborative arrangements, knowing when to terminate them, and transferring knowledge."

Organizational learning is a process in which organizations, groups in organizations, and organizational members create and improve routines to achieve certain objectives (Levitt & March, 1988). In general, routines are explicit or implicit programs that specify behavioral patterns for responding to problems and external stimulus (Ashforth & Fried, 1988; Gersick & Hackman, 1990; March & Simon, 1958). By using routines and proceeding problems "mindlessly," organizational members do not always conduct search activities for problem solution, but conserve their cognitive capabilities (March & Simon, 1958). Standard operating procedures (Cyert & March, 1963; March & Simon, 1958) and individual skills (Pinch, Collins, & Carbone, 1997; Stinchcombe, 1990) are representative examples of results of learning at the organizational and individual levels, respectively.

In this research context, routines that firms develop by accumulating alliance experience are methods for assessing prospective partners. We found in the fieldwork that, at the

individual levels, BD professionals develop their know-how and intuition regarding the ways of which they (1) scan the environment, (2) collect information about prospective partners, (3) value the collected information, (4) coordinate and facilitate due diligence processes, and (5) resolve problems in negotiating terms. One of the BD executives, for instance, commented that

> Because of the experience, I know where we go, key terms what you are looking for, certain features there have to be in every agreement, governance, who is going to make decisions, how the decisions are made, change of control, what happened to previous joint programs, commercialization, clinical trials, who is going to contact the government, insurance, and so forth. So, the more you've done, the more you know what these kinds look like. You know what is important and what is not important.

This quotes demonstrates that BD professionals develop personal routines that specify procedures in forming alliances, types of information necessary to be collected, types of contact that he has to make prior to alliance formation, and terms that he has to put in contacts.

Another example demonstrates that learning of collaborative know-how also takes place at the organizational level. One of the firms in our fieldwork routinized activities and created a checklist for assessing prospective partners for alliances, acquisitions, and other types of interorganizational relations. During the first ten years since its founding, the firm had experienced more than thirty cases of selection for its R&D alliance partners, suppliers, manufacturing partners, and acquisition targets. A BD Executive we met stated that in an executive meeting, he proposed to brainstorm ideas about (1) aspects of prospective partners that they examine, (2) types of information that they collect and evaluate, and (3) each of its sub-unit's responsibilities in the assessment processes. This brainstorming resulted in creation of the checklist that consists of the following thirteen major items: (1) financial conditions, (2) inventory, (3) permits and licenses, (4) plant, property and equipment, (5) compliance with environmental regulations, (6) intellectual property, (7) legal contracts with other firms, (8) R&D capabilities and on-going projects, (9) product strategy, (10) sales and marketing, (11) manufacturing capabilities, (12) human resources, and (13) management values. This checklist is, according to this BD executive, useful not only because the firm is now less likely to

leave crucial aspects of prospective partners unexamined prior to alliance formation, but also individuals in different sub-units recognize their own role in assessing prospective partners. The routines increase information-processing capabilities of this organization for assessing prospective partners and reducing selection uncertainty.

The second component of the internal mechanism is boundary-spanning (Aldrich, 1979; Katz & Kahn, 1973; Thompson, 1967). The crucial role of boundary-spanning is to "seal off their (organizations') core technologies from environmental influences" and to "buffer environmental influences by surrounding technical cores with input and output components" (Thompson, 1967: 19-20). Boundary-spanners scan task environment, filter and transmit collected information to decision makers, and negotiate with environment as representatives of their organizations (Aldrich, 1979).

While organizational leaders (i.e., presidents and CEOs) sometimes take initiative in forming alliances, it is generally BD professionals who identify and select appropriate alliance partners. Some BD professionals[2] described themselves "network managers", for it is BD professionals who form alliances and construct interorganizational networks. Other BD professionals called them "gatekeepers", for BD professionals scan environment, collect information relevant to alliance formation, select appropriate partners, and propose alliances to top management. One of the BD executives in the fieldwork described his primary activities in the firm:

> 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 are boundary spanners in a sense that they are "more tightly linked to the environment than others" (Aldrich, 1979: 428). In fact, more than 70 % of our interviewees

[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 occupation group that controls knowledge and skills of incumbents in BD units, it may not be correct to term them as "professionals." However, for the convenience of this research, we loosely use this term.

have doctoral degrees in the biotechnology-related fields. A crucial characteristic of BD professionals is their broad understanding of technology and products as well as strategy of competitors and alliances of other firms in the industry. A BD director commented that

> I have basic background information about companies from database. 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 biotechnology companies are doing.

Their broad understanding of the field makes it possible that they effectively scan the environment, understand research programs and clinical trials in other firms, identify alliance opportunities, conduct internal research about prospective partners, and find appropriate partners for proposing alliances. Organizations increase their information-processing capabilities for reducing selection uncertainty and finding appropriate partners by structuring the sub-units and hiring professionals dedicated to alliance formation,

The third component of the internal mechanism is technical intensity, which increases organizational capabilities to assess the technological facet of prospective partners (Cohen & Levinthal, 1990). Technical intensity connotes the degree of organizational knowledge about the state of technology.

Cohen and Levinthal (1990) claimed that the value of cutting-edge technology and innovation cannot be understood without mapping them into systems of knowledge and broad cognitive schemata, so actors are able to assess how the innovation changes the current state of technology and knowledge. Their argument implies that firms need to make investment in their own R&D activities and increase technical intensity for constructing broad cognitive schemata in order for scientists and business professionals to assess values of research activities and scientific programs in prospective partners. This effect of technical intensity on reduction of selection uncertainty becomes most evident in due diligence processes. One BD executive commented that

> 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 five 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 implicitly demonstrates that scientists and BD professionals are required to have insights in interpreting data and information presented by prospective partners in due diligence processes and judging whether or not the obtained data are trustful, reliable, reasonable, and credible, for the same data can be interpreted in different ways depending on positions that social actors occupy (Vaughn, 1996). In addition, they constantly need to update the state of knowledge for judging whether or not what is claimed to be new and valuable by prospective partners is really new and valuable. The higher degree of technical intensity reduces this facet of selection uncertainty by shaping general understanding the state of knowledge and relating emerging knowledge to the broad cognitive schemata.

In short, we found in the fieldwork that the internal mechanism consists of (1) collaborative know-how, (2) boundary-spanning, and (3) technical intensity. As an alternative mechanism, the internal mechanisms replace the relational mechanism. The internal mechanism enables firms to reduce selection uncertainty without the help of the relational uncertainty and select partners with whom they have a history of fewer interactions. Therefore,

H1: The greater the firm's collaborative know-how, the less it relies on the relational mechanism.
H2: The greater the firm's boundary-spanning activities for alliance formation, the less it relies on the relational mechanism.
H3: The greater the firm's technical intensity, the less it relies on the relational mechanism.

The Contextual Mechanism

The contextual mechanism operates on the principle that reputations of prospective partners reduce selection uncertainty. Previous research suggested three crucial roles of reputation in inter-organizational exchange. First, organizational reputations enhance power

over other organizations and capabilities to procure resource and social support (Perrow, 1961; Rao, 1994; Thompson, 1967). Second, the establishment of exchange relations with highly reputable organizations provides partners recognition, acceptance, and legitimacy from the environment (Stuart et al., 1999). Third, positive reputations of firms signal their past performance, expected future behavior, and positive attributes (Weigelt & Camerer, 1988). The last feature of reputations is relevant to this research.

In a world of imperfect information where cause-effect relations are unclear, social actors consider reputations to be a reliable source of information in screening exchange partners (Podolny, 1994; Stuart, 1998; Weigelt & Camerer, 1988). Reputations of prospective partners signal the quality of their technology and products and help the focal firms reduce this facet of selection uncertainty.

Indeed, the interviewees in the fieldwork constantly use patent and publication information of prospective partners not only for the intellectual property purposes but also for the assessment of their past commercial and technological achievement. In addition, the BD professionals also consider alliance histories of prospective partners to be important because they indicate (1) areas of research in which prospective partners are interested as collaborative programs, (2) the quality of commercialized products that they have delivered through previous alliances, and (3) the degree of prominence of their prior alliance partners. The third point is illustrated by the following story from a small bio-agricultural firm in the fieldwork. When it was looking for alliance partners who could help it apply the basic molecular technologies and enter into the human therapeutic fields, the firm obtained the government funds and initiated a research project on crop diseases with the USDA (United States Department of Agriculture). As a part of this research project, the firm made the work-in-progress presentation in the government workshop, which provided the firm an opportunity to publicize its connection with the government agency and signal the certification or endorsement for its science and technology from it (Stuart et al., 1999). The CEO told us that at least two large chemical firms visited his laboratory with an interest in collaborating with his firm just after the workshop because of this

signaling effect.

In short, we found in the fieldwork that firms are able to reduce selection uncertainty by using reputations of prospective partners. As an alternative mechanism, this contextual mechanism substitutes and replaces the relational mechanism in forming alliances. When the contextual mechanism is activated, firms decrease their reliance on the relational mechanism so as to reduce selection uncertainty without limiting their expandability and reachability of interorganizational networks. Therefore,

> *H4: The greater reputations of the firm's partner, the less it relies on the relational mechanism.*

METHODS

Sample

The unit of analysis is an alliance. In testing these hypotheses, we employed the organization-set or egocentric network analysis in which we essentially focused upon relationships between the focal firms and others (Van de Ven & Ferry, 1980; Hall, 1982; Knoke & Kuklinski, 1980; Stern, 1978). The organization-set analysis is appropriate for the purpose of this research because it enables us to examine the manner in which organizational characteristics (e.x., collaborative know-how) are related to interorganizational patterns and to trace interactions between intraorganizational capabilities and the network formation (Evan, 1966; Provan et al., 1980).

Our sample consists of 145 new (or non-repeated) R&D alliances formed in between 1995 and 1999 by 48 publicly-held firms in the biopharmaceutical industry. We first identified 285 publicly-held biopharmaceutical firms in *Recombinant Capital Biotechnology Alliance Database* (*ReCap*), *Corporate Directory of Technology Companies*, *Windhover's Healthcare Strategists*, and *Standard & Poor's Compustat*. We then conducted the proportional stratified sampling (Sedlack & Stanley, 1992) on the basis of the 1998 asset size and extracted 88 firms (approximately 30%). We ran logistic regressions and did not find significant differences

between the firms extracted and those left out in terms of the 1998 asset size, return on asset, return on investment, return on equity, and earning per share. Of the extracted 88 firms, 40 firms were removed which did not form any R&D alliances during this period. We then identified R&D alliances formed by 48 firms with *ReCap*. We selected the 1995-99 observation window, because (1) due to pressures from the Clinton administration on high pricing practices in the pharmaceutical industry, the level of competition has been increasing since the mid-1995, (2) the difficulty in procuring financial resources has changed organizational goals in a number of biopharmaceutical firms from becoming firms that develop, manufacture, and market their own therapeutics to those that exchange and sell their primary technologies and sciences to pharmaceutical firms for their survival, and (3) due to expiration of patents, large pharmaceutical firms that had based their drug discovery upon chemistry have increasingly become interested in developing biotechnology products (Standard & Poor's, 1995, 1998; Pharmaceutical Research and Manufactures of America, 1999, 2000). On average, 48 firms in our sample formed .60 R&D alliances per year from 1995 to 1999. The firm that formed alliances most in our data is Aurora Biosciences (9 alliances), while 16 firms formed only one alliance during this time period.

Dependent Variable

The dependent variable describes the degree of a history of prior interactions between allying firms and so-to-speak their "connectedness", "cohesiveness", "closeness", or "sharedness" prior to alliance formation. In order to develop this variable, we used a concept of multiplexity in network literature, which is defined as "the number of separate contacts which make up the relationship" (Scott, 1991: 68). By using prospectuses and proxies of the firms, *ReCap*, and *Biography and Genealogy Master Index*, we constructed *history of interactions* on the basis of the five dummy indicators, including (1) *direct interlocking* at time t-1 (Gulati & Westphal, 1999), (2) *indirect interlocking* at time t-1 (Gulati & Westphal, 1999), (3) *prior business ties* by time t (Gulati, 1995; Gulati & Gargiulo, 1999; Gulati & Singh, 1998), (4) *shared investor tie* at time t-1 (Nohria, 1992), and (5) *CEO social similarity* by time t (Larson, 1992; Saxenian, 1994;

Uzzi, 1996) (see Table 2).

TABLE 2 ABOUT HERE

Previous research suggests that these five dimensions portray a history of interactions that are pertinent to alliance formation.

When a board member of one of the allying firms sat on the board of the other firm at time t-1, *direct interlocking* was coded as 1. When the board members of the allying firms sat together on boards of other firms at time t-1, *indirect interlocking* was coded as 1. When the allying firms had prior business transactions by time t that include licensing, supplying, manufacturing, asset purchases, and marketing or distribution agreements, *prior business ties* were coded as 1. When the focal firm shared the institutional investors or venture capitalists with its partner, *shared investor tie* was coded as 1. When the CEOs of the allying firms (1) went to the same schools, (2) used to work in the same firms, (3) held memberships in the same social and local-development organizations, and (4) sat in executive boards of the same industrial associations by time t, *CEO social similarity* was coded as 1. We aggregated these five variables and created the dependent variable, *history of interactions*.

Table 3 is a frequency table of the five dummy indicators used for constructing *history of interactions*.

TABLE 3 ABOUT HERE

Figure 1 is a histogram of *history of interactions*.

FIGURE 1 ABOUT HERE

There are two findings from Table 3 and Figure 1. First, as we found in Table 1, both Table 3 and Figure 1 show variance in the dependent variable, *history of interactions*. The existence of this variance guarantees the minimum validity of using this dataset for the purpose of this research. Second, allying firms, at least, in our sample seem to have fewer interactions than we

expected. Indeed, Figure 1 shows that more than 60% of alliances did not involve any of prior interactions. Although one may wonder the quality of our dataset, this finding on fewer prior interactions between allying firms is actually consistent with that in Gulati and Westphahl (1999: 490) in which they found only .06 correlation coefficients between alliance formation and presence of direct interlocking. The finding in Figure 1 not only suggests that firms do not strongly rely on the relational mechanisms but also assures the quality of our dataset.

Independent Variables

In testing the effect of collaborative know-how in H1, we followed previous studies (Barkema et al., 1997; Powell et al., 1996; Simonin, 1997) and used *ReCap* to create two variables that describe organizational experience of forming R&D alliances and other types of alliances. An underlying assumption in creating these variables is that firms with more alliance experience have higher collaborative know-how (Simonin, 1997). *R&D alliance experience* contains count data that indicate the number of R&D alliances that firms had formed prior to time t. In order to measure the effect of other types of interorganizational experience (e.g. supplier, manufacturing, distributors, consultants, etc.), we also used *organizational age* as another measure of collaborative know-how, that indicates the firm age at time *t* (Gulati & Gargiulo, 1999; Powell et al., 1996).

In testing the effect of boundary-spanning in H2, we used the presence of senior BD executives in top management teams at time t-1, presuming that it indicates size of the BD unit and its impact on strategy formation and crucial decision making in firms (Welbourne & Cyer, 1999). We collected information from the "Executive Compensation" section of each annual proxy and coded *BD executive* as 1 when firms had a senior BD executive on its top management team at time t-1.

In testing the effect of technical intensity in H3, we modified the operationalization in Milkovich et al. (1991), and used the Compustat to create technical intensity by computing the financial investment in R&D activities per an employee at time t. Two remarks should be made here. First, Milkovich et al. (1991) measured it as a proportion of R&D expenditures to net

income. We divided the R&D expenditures by the number of employees because their measure captures the proportion of R&D expenditures to the net loss, rather than the net income, in the biopharmaceutical industry, where an average of the 1998 net income of the publicly-held 285 firms was – 4.19 billion dollars. Second, the Compustat sometimes reports some intrinsic accounting values for biopharmaceutical firms, and decomposes the financial investment in R&D activities into the three categories: (1) R&D expenses (XRD in the Compustat), (2) R&D investment funded by other firms or government agencies (RDS), and (3) R&D investment which was made by the firm and was not reimbursed by other firms or government agencies (RDCS) (see Powell et al., 1999). We consulted prospectuses and proxies of the firms and defined the total financial investment in R&D activities as the sum of XRD and RDCS for gaining amounts of investment that they made by themselves.

In testing the effect of reputations of partners in H4, we used their publication and patent records. Scientific achievement and intellectual properties are a crucial source of reputations in the biopharmaceutical industry where scientific research and knowledge-creation are believed to be a source of competitive advantage of firms (Barry et al, 1992; Ryan et al., 1995). We used the *Science Citation Index Database* and obtained the number of academic publications by the partner from time t-2 to t. We also used the *U.S. Patent and Trademark Office Database* and obtained the number of patents by the partner from time t-2 to t. These two data are relatively correlated (r = .71), so we aggregated them by taking the means and termed it *partner's reputation.*

Control Variables

We controlled for characteristics of alliances, firms, and their partners known to affect alliance activities and formation. We included the followings in our analysis as control variables: (1) *firm's reputation*, (3) *large pharmaceutical partner*, (4) *research alliance*, (5) *firm's market value*, and (6) *firm's assets.*

First, in order to remove effects of reputations of firms in testing H4, we simplified a method in Podolny (1994). In his status-matching research, he used four variables in

constructing the regression models, including (1) reputation score of firms when it is greater than partner's score, (2) score of firms when it is lower than partner's score, (3) score of partners when it is greater than firm's score, and (4) score of partners when it is lower than firm's score. Instead of introducing all of these variables into the regression models, we used the absolute reputation scores of the firms and their partners because we are interested in examining the effect of partners' reputations on reduction of selection uncertainty and in disentangling inter-relatedness between the relational and contextual mechanisms.

Second, we included two variables that describe characteristics of R&D alliances. The first variable indicates whether or not the partner is a large pharmaceutical firm. Alliances with large pharmaceutical firms are known to be research-outsourcing alliances in most of the cases in which large pharmaceutical firms contract out their research programs to biopharmaceutical firms (Pharmaceutical Research and Manufacturers of America, 2000; Standard & Poor's, 1998). Because what is exchanged in alliances between biopharmaceutical and large pharmaceutical firms is more or less packaged, we believe that this variable partially portraits contents of resource and knowledge exchanged in alliances. We coded partners in our sample as large pharmaceutical firms if they were listed in (1) the 1995 Fortune 500 and (2) the 1995 Standard & Poors' 500 Pharmaceutical Firm List. A list of the 18 firms identified as the large pharmaceutical firms is available in Appendix 2.

The second control variable indicates whether or not alliances involve fundamental research activities at the upstream of drug discovery and development processes. Research alliances are known to involve higher interactions between scientists across organizational boundaries and require higher coordination between them (Gulati, 1995). This expected complexity of interorganizational transactions may influence ways in which firms reduce selection uncertainty and use the relational mechanism. We used *ReCap* and coded *research alliance* as 1 if the alliance involves fundamental research activities.

Third, we also introduced two control variables that describe characteristics of the firms. *Firm's market value* is a proxy for financial performance of the firms, collected from the

Compustat. This is argued to recognize the cost of capital and the riskiness of a firm's operations and therefore better capture the "real" value of the firm than traditional accounting measures such as net income and return on investment (Dess, Lumpkin, & McGee, 1999; Lehn & Makhjia, 1996; Wiklund, 1999). *Firm's assets* are a proxy for organizational size, obtained from the Compustat. Table 4 presents descriptive statistics and correlations of the variables used in the analysis.

TABLE 4 ABOUT HERE

Statistical Analysis

We used negative binomial regressions with random effect within-group correlation structures for the following two reasons. First, the dependent variable, *history of interactions*, is a count (or frequency) variable ranging from 0 to 4. Two appropriate methods for regressions in which the dependent variable contains count or frequency data are (1) negative binomial regressions and (2) poisson regressions. We chose the former in order to avoid violating an assumption in poisson regressions that the size of variance of the dependent variable is equal to its means in our population data (Greene, 1997).

Second, we treated our data set as "pseudo" unbalanced panel data in which a firm may have more than an entry in a year and no entry in another year. This data structure required us to manage not only "between-firm" but also "within-firm" variances (Greene, 1997). One of the solutions is to control the two types of variances by creating firm and year-dummy variables, which is sometimes called the fixed-effect model and actually used in Gulati and Gargiulo (1999). We chose, instead, the random effect model as another solution because (1) a large number of parameters are not required in obtaining estimations so that we do not lose the degree of freedom and (2) the random effect model enables us to increase generalizability of findings in sampling data, rather than population data (Kennedy, 1992). Regarding the latter point, Kennedy (1992: 222) noted that "if the data are a drawing of observations from a large population (say a thousand individuals in a city many times that size), and we wish to draw

inferences regarding other members of that population, the fixed effects model is no longer reasonable; in this context, use of the random effect model has the advantage that it saves a lot of degrees of freedom." For these reasons, we viewed the data set as "pseudo" unbalanced panel data and employed negative binomial functions for estimations.

In the random effect model, there is an overall intercept and an error term with two components: $e_{it} + u_i$. The e_{it} is the traditional error term unique to each observation. The u_i is an error term representing the distance between the overall intercept and the intercept unique to ith cross-sectional unit (biopharmaceutical firms here).

As shown in Table 4, some of the variables are highly correlated. For instance, correlation coefficients between R&D experience and firm's market value and firm's assets are .77 and .82, respectively. In order to estimate the effect of multicollinearity, we employed the condition index, which was developed as a "meaningful method for determining when an inverse of a given matrix 'blow up'" (Belsley et al., 1980: 101; see also Benjamin & Podolny, 1999; Miller & Shamsie, 1996). This diagnostic technique presents a single number for each regression model that indicates whether or not multicollinearity is detrimental. Chatterjee and Price (1991) recommended that analysts should acknowledge the harmful effects of multicollinearity when the condition index exceeds 15. Belsley et al. (1980) recommends that analysts should always take corrective actions when it exceeds 30. We computed the condition index for each regression model in order to ensure its reliability and accuracy.

RESULTS

Results of negative binomial regressions with random effect within-group correlation structures are presented in Table 5.

TABLE 5 ABOUT HERE

The bottom of each column shows the condition index for each of the regression models. The increase of standard errors of the control variables in model II, III, and IV can be attributed to the additions of variables that are correlated with them (Darlington, 1990). In addition, the models

to which we added variables for hypothesis testing (model II, III, and IV) have higher condition index and therefore higher multicollinearity problem than the model containing only control variables (model I). However, the condition indexes in all of the four regression models we presented did not exceed 15 or 30, which were suggested to be a critical point in previous research (Balsley et al., 1980; Chatterjee & Price, 1991). Therefore, despite the fact that the independent variables are highly correlated as shown in Table 4, the effect of multicollinearity in the data is not detrimental.

H1 predicted that firms with the higher degree of collaborative know-how form alliances with those with which they have a history of fewer interactions. We used *R&D experience* and *organizational age* as proxies for collaborative know-how (Barkema et al., 1997; Powell et al., 1996; Simonin, 1997) and developed three different regressions for combinations of these variables. Our findings supported H1 across the different models ($p < .001$ in model II, $p < .001$ in model III, and $p < .01$ and $p < .05$ in model IV). As firms accumulate alliance experience and develop collaborative know-how, they are more likely to form alliances with those with which they have a history of fewer interactions.

H2 predicted that firms with higher boundary-spanning for selection of alliance partners form alliances with those with which they have a history of fewer interactions. Results of the coefficients of *BD executive* in Table 5 rendered moderate support to this hypothesis ($p < .01$ in model III). The non-significant findings in model II and IV can be attributed to its collinearity with *R&D experience*. Although the size of correlations between the two variables was not large ($r = .26$ in Table 4), the standard errors of *BD executive* were larger in model II and III in which we used *R&D alliances* as a proxy to collaborative know-how.

H3 predicted that firms with higher technical intensity form alliances with those with which they have a history of fewer interactions. The coefficients of *technical intensity* were not significant across the three different models, so H3 was not supported.

H4 predicted that when the partners have higher reputations, firms have a history of fewer interactions with them. An underlying argument of this hypothesis is that the contextual

mechanism as an alternative mechanism for reducing selection uncertainty replaces or substitutes the role of the relational mechanism. We obtained significant findings opposing to our expectations across the three different models ($p < .001$ in model II and VI and $p < .01$ in model III). Although our hypotheses predicted negative associations between *partner's reputation* and *history of interactions*, it turns out that they are significantly positively associated.

These findings suggest that when partners have higher reputations, firms have a history of more interactions with them. This finding is also replicated in estimating the effect of *firm's reputation*. The coefficients of this variable were negative and significant across the three different regression models ($p < .001$ in model II, III, and IV). The findings regarding *firm's reputation* suggest that when partners have lower reputations, firms have a history of fewer interactions with them. An interpretation of these consistent and replicated findings will be presented in the discussion section.

Results for *large pharmaceutical partner* which we used as a control variable also provide further insights. We found that its coefficients were positive and significant ($p < .001$ in model II, III, and IV): when partners are large pharmaceutical firms, firms have a history of fewer interactions. These findings can be considered to replicate our findings on H1 about effects of collaborative know-how and H2 about those of boundary-spanning. It is typical that large pharmaceutical firms have more alliance experience and invest more in BD activities as boundary-spanning for constructing interorganizational networks (Stuart, 2000; Stuart et al., 1999). Our results regarding *large pharmaceutical partner* indirectly replicate our findings above in that the internal capabilities and structures of firms reduce selection uncertainty and decrease organizational reliance on a history of interactions in forming alliances.

DISCUSSION AND CONCLUSIONS

The objectives of this research have been to examine (1) how organizations reduce uncertainty that they face when forming alliances and (2) how the uncertainty reduction mechanisms are interrelated to each other. The findings in our fieldwork provide support for the embeddedness approach that claims that firms embed ongoing economic transactions into pre-existing relations by building alliances upon a history of interactions for reducing selection

uncertainty. This research extends past work by proposing variations in organizational reliance on a history of interactions that result from alternative ways of managing selection uncertainty. We hypothesized on the basis of findings in the fieldwork that the two alternative mechanisms (the internal and contextual mechanisms) substitute or replace the role of the relational mechanism because they not only reduce selection uncertainty but also increase organizational expandability of interorganizational networks and reachability to heterogeneous knowledge and cutting-edge technology outside organizational boundaries.

We tested hypotheses with various archival data about biopharmaceutical R&D alliances and found that (1) the internal capabilities and structures of firms (i.e., collaborative know-how and boundary-spanning) decrease organizational use of, and reliance upon, a history of interactions in forming alliances, and that (2) firms tend to have a history of more interactions when the partners have high reputations. These findings have advanced our knowledge in the following three areas: (1) mechanisms for managing selection uncertainty, (2) the role of organizational information processing capabilities in constructing interorganizational networks, and (3) an instrumental value of embedded ties in gaining access to prominent organizations.

First, this research extends prior research on alliance formation by demonstrating how organizations reduce selection uncertainty. Although previous research has reached consensus that management of selection uncertainty is crucial for constructing effective alliance networks, this research may offer the most complete description to date of how organizations actually manage selection uncertainty and what mechanism organizations actually employ. This research complements previous work emphasizing a history of interactions by proposing the internal and contextual mechanisms as alternative ways for reducing selection uncertainty.

Second, one of the findings in regression analyses indicates that as firms develop collaborative know-how and structure subunits dedicated for managing selection uncertainty (i.e., BD units), they become less reliant upon a history of interactions in constructing interorganizational networks. This finding suggests that organizations with the higher information processing capabilities are better able to scan the environment, collect information,

conduct internal research about prospective partners, and therefore reduce selection uncertainty without the help of a history of interactions. The present investigation contributes to the embeddedness approach by joining a research stream of work that draws attention to variations of embeddedness. The internal capabilities and structures change the level of organizational path-dependency and enable organizations to disembed economic transactions and remove constraints that the embedded nature of organizations places on them. By showing how internal structures and capabilities of organizations change patterns of their interactions with the environment, this research suggests that alliance activities of firms can be more fully understood by examining not only their locations in, and structures of, interorganizational networks but also their internal attributes.

This line of argument has implications for the large body of research that addresses new forms of organizations and, specifically, virtual corporations. According to the *Business Week* (1993), virtual corporations create their competitive advantage by establishing temporal partnerships for collecting the best core competence from the environment to conduct specific projects. It emphasizes that flexible and agile formation and resolution of interorganizational networks shape organizational access to diversified resources and cutting-edge knowledge outside organizational boundaries. One of the issues that this virtual corporation model overlooks is that it does not address path-dependency and the embedded nature of economic actions as well as selection uncertainty that firms face when searching for partners that possess best competence in the environment. The finding in this research sheds light on a factor that underlies how firms become virtualized and implies that firms with the higher information processing capabilities are better able to identify appropriate partners for the purposes of specific projects even though they have a limited history of interactions.

Third, the second set of findings in the regression analyses, which address relationships between reputation and a history of interactions, provided evidence opposing to our original expectation. Although we hypothesized that firms have a history of fewer interactions when they form alliances with prominent firms because they are able to reduce selection uncertainty by

using reputation of prospective partners, it was found that firms have a history of more interactions when the partners have higher reputation.

It is probably more reasonable to reverse the predicted causal direction in interpreting this opposing finding: when firms have a history of more interactions with highly prominent firms (e.x., direct and indirect interlocking ties), they are better able to form R&D alliances with them. In other words, what we found is not about the substitutive or replacement effect of the contextual mechanism but an instrumental value of embedded ties: embedded ties enable firms to reduce status distance and gain access to resources and technology at highly prominent firms through R&D alliance formation.

A finding in the fieldwork substantiates this speculation that BD professionals intentionally use pre-existing personal rapport to alleviate a problem that they face when making contact with prominent partners for initiating discussions about potential alliance formation. A BD executive in a very successful firm commented to us that he receives a number of correspondences, phone calls, and emails everyday in which other firms and, particularly, entrepreneurial firms show their interests in collaborating with his firm because alliances with prominent firms endorse quality of their technology and science (Stuart et al., 1999). From the standpoint of entrepreneurs, his comments indicate the difficulty for them to gain priorities from his firm to initiate discussions of potential alliance formation. A BD director in a rapidly growing firm told us her way of alleviating this contact problem by taking the advantage of the instrumental value of embedded ties:

> 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?' We usually try to leverage personal relationships and people who know the other persons on the other side. When there is an existing rapport and existing relationships, it is an opportunity to leverage the existing relationships.

The instrumental value of embedded ties resides in increasing attentions from, and priorities at,

prominent firms. By facilitating the contact and feedback processes, pre-existing social networks and a history of interactions potentially increase the likelihood of alliance formation and help organizations remove status distance for constructing interorganizational networks.

This finding is pertinent to two of the previous studies about alliance formation. It supports the effect of pre-existing personal rapport on alliance formation in Eisenhardt and Shoonhoven (1995), who found that professional backgrounds and industry experiences of senior executives determine the likelihood of alliance formation of firms. It also provides an insight to a finding in Stuart et al. (1999), who found that R&D alliances with prominent firms enable biopharmaceutical entrepreneurial firms to increase legitimacy and enhance capabilities for procuring financial resources. This research implies that firms may be better able to reduce the status distances and form the endorsement alliances by making investment in developing and cultivating social networks.

Our findings also raise a crucial question for future investigation. Although we identified the three mechanisms for reducing selection uncertainty, we did not actually observe contribution of each mechanism to reduction of selection uncertainty. It is still indeterminate which of the mechanisms is effective for reducing selection uncertainty and, more importantly, under what condition each mechanism becomes the most powerful tool for finding appropriate partners. In addition, although it has been claimed that finding appropriate partners is one of the crucial factor for enhancing alliance performance, no empirical effort has been made to test this possible association. Future research should examine the role of organizational activities prior to alliance formation in determining alliance performance.

There are several other limitations in our research, most of them stemming from the restrictions of our data sets, which could be addressed by future study. First, our statistical analysis rests on the premise that organizational characteristics or attributions are closely linked with the use or activation of mechanisms for reducing selection uncertainty. We presumed, for instance, that firms activated the internal mechanism when they have accumulated alliance experience. However, one could argue that the firms with this characteristic have only

developed the potential to reduce selection uncertainty. Future research should address this issue and examine how characteristics and possible resources of firms are actually used for constructing interorganizational networks and which of the mechanisms is actually used for forming alliances.

Second, following previous research (Barkema et al., 1997; Simonin, 1997; Powell et al., 1996), this research presumed a simple positive association between accumulations of alliance experience and development of collaborative know-how. This assumption may contain two issues. For one thing, firms may not learn how to find appropriate partners regardless of their experience because, as a number of studies on organizational learning and memory suggest (e.x., Adler, 1992; Moorman & Miner, 1998; Tversky & Kahneman, 1986; Walsh & Rivera, 1991), systems of accurate and timely feedback and knowledge management programs are required for firms to learn by doing. Our data did not contain descriptions of organizational efforts to transform experience to organizational knowledge. For another, there should be alternative ways by which firms develop collaborative know-how. For instance, firms are able to acquire such knowledge by either imitating other firms or hiring BD professionals who possess such know-how. Future research should explore alternative ways of learning collaborative know-how.

Third, this research used qualitative and quantitative data of R&D alliances in a single industry. Moreover, the time frame of the quantitative data is relatively short. This restricted research design disabled us to incorporate into our scope of research the particular industry characteristics and the contextual factors that potentially influence alliance formation. For instance, our findings about the role of BD professionals implies that historical development of this occupation should change not only the number of but also patterns of interorganizational networks in this industry. Moreover, systems of patent and publication information which we used for gauging organizational reputations in this industry are not independent of institutions, including (1) patent and intellectual property systems, (2) commercial databases for scientific information, and (3) academic communities as gatekeepers of scientific knowledge. Future

research should expand its scope of research so as to include social contexts that influence alliance activities of firms.

Fourth, although we identified the three mechanisms for reducing selection uncertainty, we did not obtain empirical evidences that indicate to what extent each of the mechanisms can contribute to the reduction. This lack of understanding means that we still do not know under what condition which of the mechanism is effective for reducing selection uncertainty and constructing high-performing alliances. Given that reduction of selection uncertainty is crucial for alliance performance (Doz & Hamel, 1998), it must be important to address how ways of reducing selection uncertainty is associated with alliance formation.

Finally, our way of constructing the dependent variable, *history of interactions*, which consists of data of past behavior of organizations (i.e. time *t-1*), may impair the adequacy and accuracy of our causal statements. Indeed, our speculation on the contextual mechanism suggests that it is more reasonable to reverse the predicted causal relationships. Future research should employ alternative ways for measuring embeddedness and a history of interactions between firms.

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Table 1: Measures and Results of the Mail-Survey Data – Descriptions of Relationships between Individuals who Played the Most Influential Role in Initiating Alliance Formation Processes

Questions	Items	Freq	%
1: Descriptions of relationships: Following Marsden and Campbell (1982), we asked the subjects to indicate relationships of the two individuals.	(1) Stranger	27	60.00
	(2) Acquaintance	12	26.67
	(3) Good friend	6	13.33
	(4) Very close friend	0	0
2: Frequencies of interactions: Following Granovetter (1973), we asked the subjects how often the contact persons saw each other prior to the initial contact discuss the possibility of alliances.	Never	20	45.45
	Once a year or less	3	6.82
	Once every 6 month	5	11.36
	Once every 3 month	6	13.64
	Once a month	9	20.45
	Once a week		2.27
3: Length of relationships: Following McPherson et al. (1992), we asked the subjects how long the contact persons knew each other prior to the initial contact to discuss the possibility of alliance.	Never met	25	55.56
	Less than a month	1	2.22
	Less than a year	5	11.11
	1 - 3 years	6	13.33
	3 - 10 years	7	15.56
	More than 10 years	1	2.22
4: Mutual friends: Following Burt (1992), Knoke and Kuklinski (1982), and McPherson et al. (1992), we asked the subjects to consider the names of five close business friends of the contact person in the focal firm and how many of them were also friends of the contact person in the partnering firm.	None	28	63.64
	1	6	13.64
	2	6	13.64
	3	3	6.82
	4	1	2.27
	5	0	0.00
5: Original point of the relationships: we asked the subjects how these two individuals got to know with each other at the beginning.	They used to work in the same company.	3	6.67
	They went to the same school or university.	2	4.44
	One of them sat on the board of the other's firm.	1	2.22
	Both are committee members of other firms or other organizations (i.e. industrial associations).	2	4.44
	They met in a workshop or conference.	5	11.11
	They met when one of them visited the other's firm during her/his business trip.	12	26.67
	A venture capitalist introduced them.	1	2.22
	Someone, other than venture capitalists, introduced them.	6	13.33
	One of them found the other's name in a directory or database.	13	28.89

Note: N = 45 alliances.

Table 2: Variables

	Variables	Descriptions	Sources
Dependent Variable	*History of interactions*	Sum of the following five dummy indicators: (1) *Direct Interlocking*, (2) *Indirect Interlocking*, (3) *Prior Business Ties*, (4) *Investor Ties*, and (5) *CEO Social Similarity*	Proxy, ReCap[1], and Biography and Genealogy Master Index.
H1 (Collaborative know-how)	*R&D experience*	The firm's number of R&D alliances by time *t*	ReCap[1]
	Organizational age	Age of the firm at time *t*	The Biotechnology Directory and prospectuses
H2 (Boundary-spanning)	*BD executives*	Presence of a BD executive in the top management team at time *t* (1: yes; 0: no)	Prospectuses and proxies.
H3 (Technical intensity)	*Technical intensity*	R&D expenditure divided by the number of employees (log transformed)	Compustat
H4 (Reputation)	*Partner's reputation*	Reputation scores of partner on the basis of its patent and publication records from time t-2 to t (log transformed)	Science Citation Index and The U.S. Patent and Trademark Office
Control variables	*Firm's reputation*	Reputation scores of the firm on the basis of its patent and publication records from time t-2 to t (log transformed)	Science Citation Index and The U.S. Patent and Trademark Office
	Large pharmaceutical partner	Partner as identified as a large pharmaceutical firm (1: yes; 0: no)	ReCap, Fortune 500, and Standard & Poor's Industry Survey
	Research alliances	The alliance involves upstream research activities (1: yes; 0: no)	ReCap
	Firm's market value	Market value at time *t*	Compustat
	Firm's assets	Assets at time *t*	Compustat

Note (1): Recombinant Capital Biotechnology Alliance Database

Table 3: Frequencies of the Five Dummy Indicators of *History of Interactions*

	Dummy Indicator	Yes (1)	No (0)
1	*Direct Interlocking*	14	131
2	*Indirect Interlocking*	19	119
3	*Prior Business Ties*	15	130
4	*Investor Ties*	11	127
5	*CEO Social Similarity*	8	136

Figure 1: Histogram of *History of Interactions*

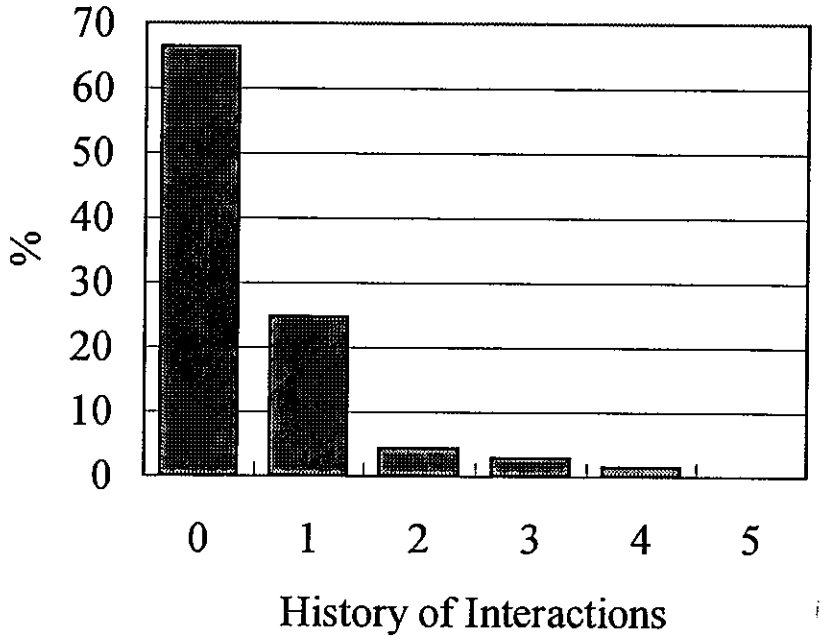

Table 4: Descriptive Statistics and Correlations

		N	Mean	S.D.	Min.	Max.	1	2	3	4
1	*History of interactions*	137	.48	.83	.00	4.00	1			
2	*R&D experience*	145	11.52	9.27	1.00	50.00	.01	1		
3	*Organizational Age*	145	8.06	5.29	1.00	27.00	-.02	.42	1	
4	*BD executive*	139	.61	.49	.00	1.00	.09	.26	.03	1
5	*Technical intensity*	115	.27	.84	.02	9.05	.21	-.16	-.08	-.11
6	*Partner's reputation*	145	3.61	2.86	-2.30	7.55	-.04	-.23	-.17	-.14
7	*Firm's reputation*	145	1.93	2.00	-2.30	6.17	-.06	.57	.22	.15
8	*Large pharmaceutical partner*	145	.34	.47	.00	1.00	-.14	-.13	-.06	-.15
9	*Research alliance*	145	.59	.49	.00	1.00	.20	.21	-.19	.17
10	*Firm's market value*	123	676.14	1002.00	14.50	4666.70	.15	.77	.35	.29
11	*Firm's assets*	143	224.90	468.52	5.62	2524.26	.03	.82	.42	.25

		5	6	7	8	9	10	11
1	*History of interactions*							
2	*R&D experience*							
3	*Organizational Age*							
4	*BD executive*							
5	*Technical intensity*	1						
6	*Partner's reputation*	.04	1					
7	*Firm's reputation*	-.05	-.13	1				
8	*Large pharmaceutical partner*	-.07	.69	-.08	1			
9	*Research alliance*	.06	-.11	.07	.07	1		
10	*Firm's market value*	-.05	-.35	.48	-.22	.10	1	
11	*Firm's assets*	-.08	-.35	.55	-.21	.07	.90	1

Table 5: Results of the Negative Binomial Regressions with the Random-effect Correlation Structures (Dependent Variable = *History of Interactions*)[1]

		I	II	III	IV
H1	*R&D experience*		-.1132 ***		-.0640 **
			(.0184)		(.0221)
H1	*Organizational Age*			-.0951 ***	-.0450 *
				(.0186)	(.0223)
H2	*BD executive*		-.1014	-.3866 **	-.1871
			(.1614)	(.1224)	(.1599)
H3	*Technical intensity*		-.0243	.0151	-.0066
			(.0520)	(.0589)	(.0563)
H4	*Partner's reputation*		.1141 ***	.0727 **	.1116 ***
			(.0304)	(.0268)	(.0348)
	Firm's reputation	-.0131	-.3265 ***	-.2611 ***	-.2822 ***
		(.0746)	(.0543)	(.0448)	(.0506)
	Large pharmaceutical partner	-.3368	-1.1890 ***	-.8638 ***	-.9407 ***
		(.2796)	(.2474)	(.2403)	(.2530)
	Research alliance	.2930	.2291	.1746	.2471 +
		(.2476)	(.1558)	(.1096)	(.1452)
	Firm's market value	.0003	.0005 ***	.0002 *	.0004 ***
		(.0002)	(.0001)	(.0001)	(.0001)
	Firm's assets	-.0003	.0018 ***	.0009 **	.0014
		(.0005)	(.0004)	(.0003)	(.0004)
	Constant	-1.3370 ***	-.1132	-.0549	-.2376
		(.2505)	(.1001)	(.1494)	(.1993)
	Wald x^2	9.26	69.8 ***	73.81 ***	72.31 ***
	The Condition Index	7.09	8.99	8.63	9.79

Note: (1) Standard errors are in parentheses.
+ p < .10; * p < .05; ** p < .01; *** p < .001

Appendix 1: Methodology of the Mail Surveys

We distributed questionnaires to BD executives or CEOs in 285 firms identified as biopharmaceutical firms in *Recombinant Capital Biotechnology Alliance Database*, *Corporate Directory of Technology Companies*, *Windhover's Healthcare Strategists*, and *Standard & Poor's Compustat*. We obtained names of BD executives if available in *Bio Business Development Directory*.

To ensure the highest possible response rates, we 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. We did not find any significant difference between non- and responding firms in terms of the 1998 *Compustat*'s data, including (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.

In the cover letter, we stated the purpose of this research, guaranteed confidentiality and anonymity, provided instructions for completing the survey sheets, and requested their participation in their study. A part of our survey packets was completely dedicated for collecting historical data of alliance formation processes. We asked the survey recipients to choose 3 recently formed alliances and redistribute separate questionnaires to those who were most familiar with each of them. We expanded the scope of the respondents because we found in the fieldwork that some BD executives are not necessarily most knowledgeable about historical details of each alliance formation process. We also limited my scope to R&D alliances from 1995 to 1999 to alleviate a recall problem (Marsden, 1990).

Appendix 2: Large Pharmaceutical Firms

We considered the following firms to be large pharmaceutical firms that were listed in the 1995 Fortune 500 and Standard & Poors' 500 in the Pharmaceutical Section.

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