RELATIVE ABSORPTIVE CAPACITY AND INTERORGANIZATIONAL LEARNING

PETER J. LANE[1]* AND MICHAEL LUBATKIN[2]
[1]*School of Business, Indiana University, Indianapolis, Indiana, U.S.A.*
[2]*School of Business Administration, University of Connecticut, Storrs, Connecticut, U.S.A., and Groupe ESC, Lyon, France*

Much of the prior research on interorganizational learning has focused on the role of absorptive capacity, a firm's ability to value, assimilate, and utilize new external knowledge. However, this definition of the construct suggests that a firm has an equal capacity to learn from all other organizations. We reconceptualize the firm-level construct absorptive capacity as a learning dyad-level construct, relative *absorptive capacity. One firm's ability to learn from another firm is argued to depend on the similarity of both firms' (1) knowledge bases, (2) organizational structures and compensation policies, and (3) dominant logics. We then test the model using a sample of pharmaceutical–biotechnology R&D alliances. As predicted, the similarity of the partners' basic knowledge, lower management formalization, research centralization, compensation practices, and research communities were positively related to interorganizational learning. The relative absorptive capacity measures are also shown to have greater explanatory power than the established measure of absorptive capacity, R&D spending.* © 1998 John Wiley & Sons, Ltd.

INTRODUCTION

Over the past decade the rules of corporate competition have changed and with them the ways in which firms use alliances. Competition is increasingly knowledge-based as firms strive to learn and to develop capabilities faster than their rivals (Prahalad and Hamel, 1990; D'Aveni, 1994; Teece and Pisano, 1994). However, the time between the identification of a problem and its arrival may not allow the firm to internally develop the knowledge and capabilities needed to respond effectively (Dierickx and Cool, 1989). This has led to a shift from traditional resource or risk-sharing alliances to alliances with learning

from partners as a primary goal (Hamel, 1991; Huber, 1991). Through 'learning alliances' firms can speed capability development and minimize their exposure to technological uncertainties by acquiring and exploiting knowledge developed by others (Grant and Baden-Fuller, 1995).

The importance of learning alliances to capability development places a premium on a firm's ability to identify, assimilate, and utilize a partner's knowledge. However, our understanding of learning alliances to date has been limited primarily to *how* they should be structured and managed. For example, researchers have examined such operational issues as when a firm may need to form a joint venture to nurture learning and how successful alliances are managed day-to-day (e.g., Kogut, 1988; Bartlett and Ghoshal, 1995; Haspeslagh and Jemison, 1991). Far less is known about *with whom* a learning alliance should be formed; i.e., when a 'student' firm seeks to develop new capabilities by engaging in

a learning alliance, what criteria should be used in selecting its 'teacher'?

To begin to address this question, we develop and test a model of interorganizational learning based on Cohen and Levinthal's (1989, 1990) theory of absorptive capacity. They define absorptive capacity as a firm's ability 'to recognize the value of new, external knowledge, assimilate it, and apply it to commercial ends' (1990: 128). This definition succinctly captures the steps involved in the interorganizational learning process. Cohen and Levinthal view absorptive capacity as a firm-level construct, an ability the firm develops over time by accumulating a relevant base of knowledge. We shift the unit of analysis of their construct from the firm to the 'student–teacher' pairing (the learning dyad). Simply put, we argue that the ability of a firm to learn from another firm is jointly determined by the relative characteristics of the student firm *and* the teacher firm.

We will propose that a student firm's absorptive capacity, its ability to value, assimilate, and apply new knowledge from a learning alliance partner, depends upon: (a) the specific type of new knowledge offered by the teacher firm; (b) the similarity between the student and the teacher firm's compensation practices and organizational structures; and (c) the student firm's familiarity with the teacher firm's set of organizational problems. We test our model using a sample of R&D alliances between pharmaceutical and biotechnology companies, using measures of a firm's scientific knowledge-base and research capabilities, and measures of how similar the 'student' and 'teacher' firms are in those areas. Our measures of firm knowledge utilize a type of bibliometric data not widely used in strategy research.

INTERORGANIZATIONAL LEARNING AND CAPABILITY DEVELOPMENT

Every industry has its own 'industry recipe' for success, the conventional wisdom on how a firm's resources, knowledge, and processes should be combined and utilized to cope with the environment (Spender, 1989). However, the recipe only provides guidance in determining the activities a firm must accomplish. Differences in firms' histories and resources, particularly knowledge, lead each of them to develop a unique set of capabilities to accomplish those activities. A firm's knowledge includes both easily communicated articulable knowledge and tacit knowledge which is difficult to define due to its interconnections with other aspects of the firm such as its processes and social context.

When a firm's capabilities build on tacit knowledge and are rare, imperfectly tradable, and costly to imitate, they are the basis of superior performance (Barney, 1991, 1995; Spender, 1996). However, their strategic value to a firm will naturally erode over time as substitutes appear and new competitive problems emerge. Firms tend to initially respond to diminishing prospects by adapting their existing capabilities or developing new capabilities from existing organizational knowledge (Leonard-Barton, 1992; Walsh and Ungson, 1991). Should these responses prove unsatisfactory, a firm may turn to external knowledge sources in an effort to develop capabilities more divergent from its existing set.[1]

There are three methods for learning new external knowledge—passive, active, and interactive—and each provides a different type of knowledge. Passive learning occurs when firms acquire articulable knowledge about technical and managerial processes from sources such as journals, seminars, and consultants. More active forms of learning such as bench-marking and competitor intelligence can provide a broader view of other firms' capabilities. Because this learning occurs at arm's length, only the observable portion of another organization's experience can be acquired (Huber, 1991): the 'who, what, when, and where.' However, both passive and active learning have limited capacities to contribute to valuable new capabilities. The very fact that the knowledge they provide is articulable (observable) means that it is no longer rare, imperfectly traded, or costly to imitate (Spender, 1996). Such readily transferred knowledge may guide capability development much like industry recipes, but they do not permit a firm to add unique value to its own capabilities.

This can be done through interactive learning between the two firms. With this method, a student firm gets close enough to the teacher firm to

---

[1] Alternatively, the firm could fail to acknowledge that its established capabilities are no longer effective and, consequently, not develop the new capabilities needed to adapt to the environment. For an in-depth discussion of why some capabilities become rigidities, see Leonard-Barton (1992).

understand not just the objective and observable components of the teacher's capabilities, but also the more tacit components: the 'how and why' knowledge. This knowledge is embedded in a firm's social context, making it more unique, less imitable, and thus better able to create strategic value (Spender, 1996). Learning such complex knowledge requires face-to-face interactions between student and teacher; i.e., the *interorganizational learning* of alliances, not the vicarious learning of bench-marking (Daft and Huber, 1987; Huber, 1991). However, as we will discuss in the next section, face-to-face interactions are necessary, but not sufficient, for effective interorganizational learning.

RELATIVE ABSORPTIVE CAPACITY AND INTERORGANIZATIONAL LEARNING

Research on cognitive structures and problem-solving (Ellis, 1965; Estes, 1970; Bower and Hilgard, 1981) concludes that an individual's learning is greatest when the new knowledge to be assimilated is related to the individual's existing knowledge structure. Extending these insights from the individual level to the organizational level, Cohen and Levinthal (1990) coined the term 'absorptive capacity' which they define as a firm's general ability to value, assimilate, and commercialize new, external knowledge. They suggested that an organization's absorptive capacity tends to develop cumulatively, be path dependent, and builds on prior investments in its members' individual absorptive capacity. They further suggested that the incentives for investing in absorptive capacity are themselves driven by three industry-wide effects: demand, appropriability, and technological opportunity.[2] Using R&D spending as a

proxy for a firm's willingness to invest in absorptive capacity, Cohen and Levinthal (1990) found empirical support for their industry-level predictions.

Other researchers have explored internal determinants of absorptive capacity. Pennings and Harianto (1992a, 1992b) examined the role of absorptive capacity in the adoption of video banking by large U.S. banks. They conclude that experience matters more than asset investments; i.e., whether or not a firm adopted video banking was largely determined by its cumulative experience with information technology and linkages to other firms, especially technology firms and not its own investment in systems and equipment. Nicholls-Nixon (1993) expanded on Pennings and Harianto's findings by examining the role of absorptive capacity in pharmaceutical firms' responses to the technological discontinuity created by the emergence of biotechnology. She measured pharmaceutical firms' absorptive capacity three ways: the number of biotechnology patents the firm held, the number of new products it had on the market or under development, and its reputation for expertise in the human healthier applications of biotechnology. She found that firms with high levels of absorptive capacity invested more in their own R&D, utilized alliances, had more in-house expertise with relevant technologies, and managed communications with alliance partners more effectively. In keeping with our earlier contention that the mere existence of face-to-face meetings is not sufficient to ensure interorganizational learning, Nicholls-Nixon (1993: 191) concluded:

> The findings from this study suggest that it is dangerous to regard strategic alliances as a panacea for staying in touch with rapidly changing technological environments. This is because the benefits associated with the use of strategic alliances are not automatic. Conscious management action is required . . . to ensure that externally sourced technology can be acquired and integrated into the firm's technological capabilities.

Nicholls-Nixon defined 'conscious man-

---

[2] Demand for an industry's product(s) and, more importantly, the elasticities of that demand, determine the economic incentives for acquiring and utilizing new knowledge. For example, the greater the net pay-offs to price reduction (price elasticity), the greater the incentive the firm has to learn more efficient production processes. Appropriability refers to the ability of firms within an industry to capture the profits created by their innovative activities. If a firm in the industry can routinely capture most of the profits from its innovations, appropriability is low. If, however, the knowledge it creates tends to spill over to rivals who can also capitalize on it, then appropriability is high. The level of spillovers in an industry, in turn, is believed to be a function of the strength of patents, the ability to keep innovations secret, and the value of first-mover advantages.

Cohen and Levinthal (1989, 1990) discuss technological opportunities in terms of the quantity of knowledge available from outside the industry (i.e., university or government labs) that complements the firm's own knowledge and allows it to be leveraged.

agement' as the mastery of alliance management skills (1993: 200). As we will point out in the next three sections, 'conscious management' alone may not be sufficient to ensure interorganizational learning. Following the theory of absorptive capacity, interorganizational learning is also dependent on the ability of the student firm to recognize and value new external knowledge, to assimilate that knowledge, and to commercially utilize it.

The ability to recognize and value new external knowledge

Cohen and Levinthal suggested that a firm's prior scientific or technological knowledge must meet two criteria in order for it to be relevant enough to facilitate understanding and valuing new external knowledge (1990: 136). First, it must possess some amount of prior knowledge basic to the new knowledge. Basic knowledge refers to a general understanding of the traditions and techniques upon which a discipline is based. Understanding the relevant basic knowledge permits the student firm to understand the assumptions that shape the teacher's knowledge and thereby be in a better position to evaluate the importance of the new knowledge for its own operations.[3] Simply put, a chemistry scholar may not be able to appreciate advances in biotechnology without first having an understanding of basic biological sciences. Second, some fraction of the teacher's knowledge 'must be fairly diverse to permit effective, creative utilization of the new knowledge' by the student (Cohen and Levinthal, 1990: 136). That is, student firms have the greatest potential to learn from teachers with similar basic knowledge but different specialized knowledge. Indeed, the acquisition of new specialized knowledge is often the motivation for establishing interorganizational collaborations (Hamel, 1991). These criteria suggest that a student firm's ability regarding the first dimension of absorptive capacity, valuing

external knowledge, is largely determined by the *relative* relationship between its knowledge and that of its teacher. Given the relationship between absorptive capacity and interorganizational learning:

> *Hypothesis 1: The relevance of the student firm's basic knowledge to the teacher firm's knowledge base will be positively associated with interorganizational learning.*

> *Hypothesis 2: The relevance of the student firm's specialized knowledge to the teacher firm's knowledge base will be negatively associated with interorganizational learning.*

It is important to note that the hypotheses predict one-way interorganizational learning (i.e., one teacher and one student). This is not to say that two-way learning in alliances is rare. On the contrary, alliances have been described as 'learning races' in which each partner seeks to accomplish its learning goals first (Hamel, 1991; Hamel, Doz, and Prahalad, 1989). However, we believe that the factors that influence one-way learning also effect two-way learning. Thus, our hypotheses are intended to represent the fundamental contingencies that influence absorptive capacity in all interorganizational learning.

The ability to assimilate new external knowledge

Should a firm possess the relevant prior knowledge needed to recognize valuable external knowledge, the next challenge it faces is how to internalize it. Following Nelson and Winter (1982), Cohen and Levinthal (1990: 132–134) noted that the assimilation process is influenced by a firm's tacit, firm-specific knowledge regarding its established systems for processing knowledge. We can think of a firm's knowledge-processing systems as being analogous to a computer's operating system as both establish the ground rules for how knowledge is acquired, stored, and transferred. Just as a computer program is based on the ground rules of a given operating system and will only function correctly on other computers using the same ground rules, a firm's knowledge is grounded, or embedded, in that organization's established knowledge-processing systems. Indeed, it is the embed-

---

[3] This is especially critical when dealing with highly abstract or scientific knowledge. Zolo (1989), for example, observes that all scientific fields are located within semantic circuits in which the meanings of concepts vary with each field's contexts. In order to evaluate the limits and validity of a scientific concept, 'it is crucial to refer [back] to the specific "community"—together with the historical and sociological conditioning of that community—which has produced it' (Zolo, 1989: 170).

dedness of valuable, firm-specific knowledge that is the basis of a firm's capabilities (Leonard-Barton, 1992; Teece and Pisano, 1994) and the ultimate source of sustainable competitive advantage (Spender, 1996). It follows that if a student firm wishes to learn some of the valuable knowledge developed by another firm, the student firm's ability to internalize that knowledge is greater when their knowledge-processing systems are similar.

While firm's processing of knowledge is itself unobservable, it nevertheless influences other, more readily observable organizational practices (Schein, 1985). For example, compensation practices vary from highly algorithmic and mechanistic to highly experiential and situation-specific (Kerr, 1985; Balkin and Gomez-Mejia, 1990). Where a firm falls along this continuum may influence its performance (Kerr, 1985; Kerr and Slocum, 1987; Balkin and Gomez-Mejia, 1990), diversification strategies (Salter, 1973; Gomez-Mejia, 1992), and the strategic position and performance of its business units (Rappaport, 1986). Compensation practices may also influence a firm's innovative and problem-solving abilities at both the divisional level (Quinn and Rivoli, 1991; Hoskisson, Hitt and Hill, 1993) and business unit level (Galbraith and Merrill, 1991). For example, Henderson and Cockburn's (1994) study of chemical pharmaceutical firms found that the more they emphasize publications and external reputation when evaluating their research staff, the higher their rate of new drug development.

We can infer from the compensation literature that the similarity of two firms' compensation policies serves as one proxy for the similarity of their knowledge-processing systems and norms. This suggests that the second dimension of absorptive capacity, the ability to assimilate new external knowledge, is in part a function of the relative similarity of the student and teacher firms' compensation practices. By extension, the relationship between compensation practices and interorganizational learning can be stated as:

Hypothesis 3: The similarity of the student firm's and teacher firm's compensation practices will be positively associated with inter-organizational learning.

A second proxy for a firm's knowledge-processing system is its organizational structure; i.e., the degree of formalization and centralization used by the firm when allocating tasks, responsibilities, authority, and decisions (Child, 1984). Structure is important to how firms process knowledge because organization members interact not only as individuals, but also as actors performing organizational roles. Structure represents the codification of the organization's historic pattern of roles (Walsh and Ungson, 1991). Structure also reflects and stores knowledge about the organization's perception of the environment (Tushman and Nadler, 1978) and influences an organization's communication processes (Guetzkow, 1965). Finally, structure is strongly related to an organization's problem-solving behaviors (e.g., Burns and Stalker, 1961; Thompson, 1967; Lawrence and Lorsch, 1967). For example, Galbraith and Merrill (1991) extended the work of Miller and associates (Miller, 1987; Miller and Droge, 1986; Miller, Droge, and Toulouse, 1988) by examining the relationship of decision centralization and organizational process formalization to innovation in technology intensive firms. Galbraith and Merrill (1991) found that the centralization of R&D decisions was negatively related to the level and quality of innovation, while formalization had an ambiguous relationship.

To the extent that a firm's organizational structure is interlinked with its knowledge-processing systems, then a firm's valuable knowledge is embedded in both. It follows that if student and teacher firms have very different organizational structures, the student will have difficulty assimilating knowledge from the teacher. Reframing the proposed link between knowledge-processing similarities and the ability to assimilate new external knowledge in terms of organizational structure suggests:

Hypothesis 4: The similarity of the student firm's and teacher firm's organizational structures will be positively associated with inter-organizational learning.

The ability to commercialize new external knowledge

Absorptive capacity implies not only an ability to value and assimilate new external knowledge, but also an ability to commercially apply it to achieve organizational objectives. Cohen and Lev-

---

...

inthal (1990: 140) suggest that the degree to which the outside knowledge is targeted to the student firm's needs and concerns will influence the ease of learning and utilization. Put differently, the more experience the student and teacher firms have in solving similar types of problems, the easier it will be for the student firm to be able to find commercial applications for the newly assimilated knowledge. As such, there is a subtle but important difference between this dimension of relative absorptive capacity and the two prior dimensions. The first dimension is the similarity of scientific, technical, or academic knowledge, the '*know-what*' portion of the student's and teacher's knowledge bases. The second dimension is the similarity of the two firms' knowledge processing, the '*know-how*' portion of their knowledge bases. This last dimension focuses on similarities in the student's and teacher's commercial objectives, the '*know-why*' portion of their knowledge.

While many things can influence a firm's commercial objectives, and the objectives themselves vary over time, there tends to be a common thread running through them, a 'dominant logic' (Prahalad and Bettis, 1986). A firm develops preferences for projects of a given type, size, and risk level, and favors strategies dependent upon certain key success factors, stages of product life cycle, or product–market positions (Grant, 1988). These preferences permit a firm to develop expertise in using information in specific ways to cope with a well-defined set of organizational problems. However, they are also a source of organizational rigidity and limit the firm's ability to effectively manage other types of projects and problems (Leonard-Barton, 1992). Mismatches between a firm's dominant logic and the projects or problems it must contend with are not easily addressed. Dominant logics change slowly and rarely in the absence of a crisis (Prahalad and Bettis, 1986; Bettis and Prahalad, 1995; Hedberg, 1981).

The evidence that a firm's dominant logic determines how it applies knowledge has implications for the commercialization of new external knowledge. Even if the student firm understands the know-what (scientific knowledge) and the know-how that shaped it (the knowledge-processing systems), its ability to commercially apply the new knowledge will largely depend on the degree to which its know-why (dominant

logic) overlaps with the teacher's. No two firms have identical dominant logics. However, the more familiar the student is with the types of problems and projects that the teacher prefers, the more readily it will be able to commercially apply new knowledge from that teacher:

Hypothesis 5: The proportion of the teacher firm's organizational problem set that the student firm shares will be positively associated with interorganizational learning.

METHODS

The sample

The sample for this study was drawn from the population of R&D alliances between pharmaceutical and biotechnology companies. The emergence of biotechnology in the late 1970s was a 'competence destroying' technological change (Tushman and Anderson, 1986). Accordingly, many pharmaceutical firms created alliances with biotech firms to keep abreast of new technological developments and to create opportunities to learn the new drug discovery capabilities (Arora and Gambardella, 1990; Pisano and Mang, 1993). In return, the pharmaceutical firms offered biotechnology firms access to production and marketing capabilities and, in some cases, capital (Pisano and Mang, 1993). Thus, while these alliances have benefited both partners, they have been largely exercises in one-way learning with the pharmaceutical firms 'students' and the biotech-nology firms 'teachers'.

We identified our sample using the April 1995 edition of BIOSCAN, the most complete reference for pharmaceutical industry collaborations (Shan, Walker, and Kogut, 1994). Several additional criteria were used in identifying the sample. Alliances whose stated objective was other than research and/or development were excluded. Only collaborations involving human therapeutics and diagnostics were included to hold constant certain technological, institutional, and industry factors, a convention followed by others who have studied these alliances (e.g., Pisano and Mang, 1993; Shan *et al*., 1994). Only nonequity collaborations were included, again in keeping with prior research on these alliances. BIOSCAN listed 85 alliances that met these criteria. To ensure that sufficient time had passed to permit

assessments of alliance performance, only the 72 alliances begun between January 1985 and November 1993 were included in the sample. We then interviewed executives of these firms by telephone to verify the information in BIOSCAN, and found that the status of three of the alliances had changed. This lowered the sample size to 69 alliances representing 22 biotechs and 48 pharmaceutical firms.

Data collection

We collected data from two primary sources. First, we used a panel of six experts to evaluate the performance of the 69 alliances in the sample. These experts were senior competitive intelligence analysts for six major pharmaceutical firms who regularly monitor the R&D development efforts such as these alliances. We asked each expert to evaluate each alliance using a card-sorting technique. Each card contained information about one alliance (partners' names and the product or research area) and a series of questions concerning the performance of the alliance for the pharmaceutical firm. Each card also contained a box to be checked if the respondent was not familiar with that particular alliance. After the cards were scored, the experts sorted them into piles based on their assessment of each alliance's overall performance. These piles were then placed in envelopes prelabeled with performance ratings (1–7 plus 'Not Familiar'). The envelopes were bundled into a return envelope, and mailed to the researcher. Five out of the six experts returned complete exercises. However, two of the responding experts were familiar with less than half the alliances and were dropped from the analysis.

The second source of primary data was a two-page instrument regarding compensation practices and organizational structure (described in the next section). Following previous research on compensation practices (Cook, 1981; Gomez-Mejia, 1992; Tosi and Gomez-Mejia, 1989; Weber and Rynes, 1991) we sent the survey instrument to the top HRM executive responsible for compensation in each of the 69 pharmaceutical and biotechnology firms in our sample.

Collection of the survey data posed a major challenge given the small initial sample size, industry norms regarding secrecy, and the fact that the study's unit of analysis is the learning

dyad, thereby requiring useable responses from both alliance partners. Accordingly, several steps were taken to maximize the response rate.[4] These steps yielded 52 responses (36 biotechnology and 16 pharmaceutical)—74 percent of the firms surveyed—but complete responses from only 31 of the 69 learning dyads (45% of the alliances in the sample).

We also used two sources of secondary data. First, we obtained R&D spending by pharmaceutical firms from the Moody's manuals. Second, we used bibliometric data to measure the knowledge bases and organizational problem sets of the alliance partners. Bibliometric data have been used in a variety of academic fields to reveal patterns in scholarly research.[5] The bibliometric data used in this study were obtained from the Center for Research Planning (CRP). CRP tracks the formation, evolution, and interrelationships of research communities through biannual co-citation analyses (a form of network analysis) of scientific and technical publications.[6]

---

[4] First, the survey recipients identified through BIOSCAN were contacted by telephone and their agreement to participate was obtained. Second, the confidentiality of the responses was emphasized, including the use of explicit nondisclosure statements in a few cases. Third, Dillman's (1978) 'total design method' for data collection was adopted as a general guide to data collection. Dillman's methodology was updated using priority communications. Surveys were sent by 2-day express delivery, two reminders were sent by fax, and a final reminder made by telephone. A duplicate copy of the survey was sent along with each reminder as well as an invitation to fax back the completed survey. Finally, a 'letterhead research center', the Center for Strategic and Technological Alliance Research (CSTAR), was created to improve the perceived status of the research project. Zajac (1990) successfully used this technique in his study of CEO selection, succession, and compensation.

[5] Bibliometric data are indicators of research activity and knowledge created through the application of mathematics and statistical methods to book and other forms of communication (Pritchard, 1969). Bibliometric analysis of patterns of scholarly research in a variety of fields including strategic management (Park and Gordon, 1996), economics (Cox and Chung, 1991), finance (Alexander and Mabry, 1994; Borokhovich, Bricker, and Simkins, 1994; Chung and Cox, 1990), industrial relations (Gordon and Purvis, 1991), and cross-cultural psychology (Vijver and Lonner, 1995). Bibliometric analysis is used for science, technology, and R&D management by corporations (Franklin and Johnston, 1988; Healy, Rothman, and Hock, 1986) as well as governments (Hicks, 1987; Mombers *et al.*, 1985).

[6] An Appendix providing a more detailed explanation of the Center for Research Planning data bases and suggestions for working with them is available upon request from the first author.

The dependent variables

The dependent variables in this study are related to the pharmaceutical firm's success at inter-organizational learning within the alliance. Using a 5-point Likert-type scale and the deck of alliance cards, the experts were asked to evaluate how the alliance has helped the pharmaceutical firm in terms of learning new skills or capabilities and technology or research developments (1 = very poorly; 5 = very well) as well as which partner benefited most from knowledge spillovers (1 = biotechnology firm; 5 = pharmaceutical firm). We found the interrater reliability for all the experts to be high (0.85), thereby allowing us to average their responses for each performance measure for each alliance. Further analysis showed that the three performance measures based on the experts' averages had a high degree of covariance (Cronbach's alpha = 0.88). Accordingly, we summed the three performance measures to create an interorganizational learning index and used the index as the study's dependent variable.

The independent variables: Knowledge bases and problem-set similarities

We used data from the 1992 and 1994 CRP proprietary data base to calculate the measures for Hypotheses 1, 2, and 5. Although the starting dates of the alliances in the sample range from January 1985 to November 1993, more than half of the alliances began in January 1992 or later. That, combined with the time lag in publishing research, makes the 1992 and 1994 data bases the most appropriate for assessing the firms' knowledge bases. We then ran several analyses to test for the underreporting of research by firms in older alliances, but found no bias.

Commercializing new knowledge

We used company-wide research community lists to develop a measure to test Hypothesis 5: the overlap between the student's and teacher's dominant logics. As noted earlier, firms can differ in their dominant logics in a number of ways. However, prior research suggests that the product development process largely defines firm dominant logics in both the pharmaceutical and biotechnology industries (Klavans, 1994; Hender-

son and Cockburn, 1994; Pisano, 1994). The projects and problems that these firms prefer can be defined in terms of the types of therapeutic and diagnostic products they develop, and the medical conditions or diseases those products address. Consequently, we measured the overlap of the student's and teacher's organizational problem sets by simply counting the number of research communities that both alliance partners had published in during the period covered by the CRP data. The more communities shared by the partners, the greater the overlap of their problem sets should be, and the more successful the student's interorganizational learning, all else being equal.

Understanding new knowledge

Developing measures for Hypotheses 1 and 2 (relevance of basic and specialized knowledge) was more complex. First, we needed a way to differentiate basic and specialized knowledge. Discussions with industry experts provided a solution: for both pharmaceutical and biotechnological research, biochemistry is the basic knowledge. Simply put, you cannot do research in either of these two fields without a basic knowledge of biochemistry. Yet at the same time, biochemistry is a broad discipline, and individual pharmaceutical and biotechnology firms differ in the areas of biochemistry in which they are knowledgeable. Indeed, biochemistry is the largest discipline in the CRP data base, being associated with almost 10,000 research communities. Accordingly, we defined the relevance of 'basic' knowledge as the overlap between the student and teacher firms' biochemistry knowledge. Similarly, we defined 'specialized' knowledge as the overlap in their knowledge of other, more specialized areas such as neurology, endocrinology, and so on.

Having made this distinction, our second challenge was to develop a measure of 'breadth' of understanding for each type of knowledge. We used the CRP data to measure each firm's involvement or participation in each of the scientific disciplines based on its publication record. The CRP data allow us to determine the maximum number of research communities that have applied a particular scientific discipline's knowledge. While it is unlikely that any firm will apply its own disciplinary knowledge to all these linked research communities, it will apply it to some.

Therefore, we measured participation breadth of knowledge as the percentage of research communities associated with a scientific discipline in which a firm was active. In keeping with the norms of bibliometric analysis, we assume that the more uses a firm has for the knowledge of a given scientific discipline, the broader its understanding of that discipline. As such, the firm's participation rate captures the breadth of 'know-what' that the firm has in each discipline.

We found that the participation rates that we calculated were skewed by the size of the discipline, as might be expected; it is easier to achieve a high participation rate in a discipline that influences 10 research communities than a discipline drawn on by 10,000 research communities. To adjust for this, the participation rates were weighted by the square root of the discipline size (the number of research communities) to determine a weighted participation rate, or WPR, for each of a firm's disciplines. To be conservative we calculated each WPR for each of a firm's disciplines twice using the 1992 and 1994 data, and then averaged the two. We ran a limited test of validity of the WPRs using the panel of five industry experts, and found a high level of convergence. This finding is especially encouraging given the abstractness of the construct being measured—firm knowledge.

In keeping with the dyad unit of analysis, we then compared the alliance partners' WPRs to determine relevance of the student firm's knowledge base to that of the teacher. First, we standardized the biotechnology firm's WPRs (mean = 5, S.D. = 1) to establish the relative importance of each discipline to that firm's research. We then multiplied the standardized scores by the pharmaceutical firm's corresponding WPRs. This adjusts the pharmaceutical firm's WPRs for each discipline's importance to the biotechnology firm and converts them to a knowledge relevance score (KRS).

In summary, Hypothesis 1 predicts that relevance of the student firm's basic knowledge to the teacher firm's basic knowledge is positively associated with interorganizational learning. We measured this relevance using the KRS for biochemistry for the alliance. Hypothesis 2 addresses the role of relevance of specialized knowledge. We measured specialized knowledge relevance by summing all the KRSs for all disciplines (except for biochemistry) used by the alliance partners.

The independent variables: Knowledge-processing similarity

Hypothesis 3 predicts a positive association between the similarity of the alliance partners' organizational structures and the student firm's interorganizational learning. We measured each firm's structure in terms of the formalization of management practices and the extent to which decisions are centralized, using scales taken from Galbraith and Merrill (1991). They adapted Miller and associates' centralization and formalization scales (Miller, 1987; Miller and Droge, 1986; Miller *et al.*, 1988) for use with R&D intensive organizations. Centralization is measured with a seven-item scale (four items for R&D decisions, three items for management decisions) and formalization with a 10-item scale (five items for upper management, five for lower management). All items use a 7-point Likert-type scale. When the responses from the 37 firms (12 pharmaceutical and 25 biotechnology) were analyzed, neither the centralization nor formalization scales demonstrated reliability. However, further investigation revealed that the subscales for business and research centralization were negatively correlated (−0.14) as were the subscales for upper and lower management formalization (−0.21). As the Cronbach's alphas for the subscales were acceptable (upper formalization = 0.74; lower formalization = 0.77; business centralization = 0.65; research centralization = 0.76), the four subscales were used separately. We computed partner similarity scores from the subscale scores of each alliance partner following the procedure used by Judge and Ferris (1993).[7] Hypothesis 3 was then tested using all four measures of organizational structure similarity: (1) upper management formalization; (2) lower management formalization; (3) business decision centralization; and (4) research decision centralization.

Hypothesis 4 predicts a positive association between the similarity of the alliance partners' compensation practice and the student firm's interorganizational learning. We adapted Gomez-Mejia's (1992) basis of pay scale to differentiate

---

[7] The absolute difference between each partner's compensation practices score was divided into 1 to create a compensation similarity measure. Note that when the alliance partners have identical scores (no difference), this calculation produces a divide-by-zero error. In such cases, the similarity measures were manually rescored as 1.00 (total similarity).

between the use of algorithmic compensation (pay based on position, tenure, etc.) and experiential compensation (pay based on individual skills, performance, and contribution to the company). Specifically, we used 10 items that came directly from this scale and modified an 11th.[8] The modified item has to do with time horizon of pay. Discussions with managers in biotechnology and pharmaceutical firms suggested that the time horizon differences among their compensation plans have less to do with the performance incentives measured by Gomez-Mejia than with the use of stock options. Finally, we added two additional items having to do with the firm's emphasis on publications and reputation in the outside scientific community in evaluating research staff. Henderson and Cockburn (1994) found both of these to be important, and somewhat unique, to pharmaceutical firms. In summary, the final compensation instrument included the 10 Gomez-Mejia items, the stock option item, and the two items on publications and reputation, all based on 7-point scales. We found these 13 items to have a moderately high level of covariance (Cronbach's alpha of 0.62) and therefore summed them to create a compensation index for each firm. We then converted the compensation index scores to similarity measures using the procedure described for the organizational structure variables.

The control variables

This study included four control variables. First, we measured the pharmaceutical firm's average R&D spending (R&D/sales) for 1992–94 in order to capture differences in student firms' commitment to developing their knowledge bases. Recall that Cohen and Levinthal (1990) used this same measure as a proxy for a firm's absorptive capacity. Thus, by including this measure in our model as a control, we can better assess the value added by our three-dimensional, relative absorptive capacity construct.

---

[8] Gomez-Mejia's scale uses 19 items to capture eight dimensions of the basis for pay using large, publicly traded manufacturing firms. However, several of the dimensions included in this scale are not relevant to the firms studied by this study, and only 10 of the 19 items were used. For example, the dimension 'business vs. corporation as the unit of analysis for performance pay' is irrelevant for most of the biotech firms as they are single-unit companies.

Second, we included three knowledge similarity interaction terms: (1) the relevance of biochemical knowledge and the number of shared research communities; (2) the interaction of the relevance of nonbiochemical knowlege and the number of shared research communities; and (3) both forms of knowledge relevance (biochemical and nonbiochemical). Again, our rationale comes from Cohen and Levinthal (1990: 136), who state that some fraction of the teacher's knowledge 'must be fairly diverse to permit the effective utilization of new knowledge.' From this statement we infer that while some similarity of knowledge is essential, too much knowledge similarity may reduce opportunities for learning. There is no theoretical reason for favoring one interaction over the others, and their high degree of collinearity (0.79, 0.86, 0.91) prohibits entering them all into one model. Consequently, each control interaction will be used in a different model and the results compared.

RESULTS

Descriptive statistics and correlations

The descriptive statistics and correlations are presented in Table 1. None of the variables suffers from range restriction and all exhibit multivariate normality. The two formalization measures have different relationships with learning. The similarity of upper management formalization is negatively associated with the interorganizational learning index ($p < 0.01$) while lower management formalization is positively associated ($p < 0.10$). In contrast, the two centralization similarity variables—management decisions and research decisions—are not correlated with the dependent variable. Interestingly, similarity of management decision centralization is correlated with the similarity of compensation practices (0.37, $p < 0.05$). This suggests that alliance partners who make business decisions in similar fashions tend to reward their people in similar ways. The similarity of research decision centralization has a weak negative correlation with pharmaceutical firm R&D spending (−0.29, $p < 0.10$). This may indicate either a problem with control, or that research is facilitated by decentralized decision making. The negative correlation between shared research communities and R&D spending (−0.48, $p < 0.01$) is unexpected

Table 1. Descriptive statistics and Pearson correlations

Variable	mean	S.D.	1	2	3	4	5	6	7	8	9
1. Interorganizational learning index	8.44	1.79									
2. R&D spending	0.11	0.03	−0.18								
3. Biochemical knowledge	16.70	9.28	−0.04	0.17							
4. Other knowledge	35.13	22.81	−0.06	0.01	0.25						
5. Formalization—upper	0.37	0.34	−0.43*	0.13	0.01	−0.26					
6. Formalization—lower	0.48	0.41	0.34†	−0.14	−0.13	−0.28	0.14				
7. Centralization–mgmt.	0.43	0.36	−0.12	0.02	0.14	−0.05	−0.16	0.28			
8. Centralization—R&D	0.40	0.35	−0.03	−0.29†	0.02	0.19	0.01	−0.21	0.18		
9. Compensation	0.20	0.23	0.13	−0.05	0.19	−0.08	−0.26	−0.22	0.37*	0.04	
11. Research communities	9.22	10.20	0.20	−0.48**	0.19	0.59**	−0.24	−0.05	−0.01	0.21	−0.10

[a]$N = 31$
†$p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

and suggests a trade-off between internal R&D and alliances for learning purposes.

Hypothesis tests

Table 2 presents the results of the multiple regression analyses using the interorganizational learning index as the dependent variable. Three models were tested consisting of the control variable (R&D/sales), the eight relative absorptive capacity variables, and one of the three interaction terms (to control for too much knowledge similarity). All three models are highly significant (Models 1 and 3 at $p < 0.001$, Model 2 at $p < 0.01$) and explain a large amount of the variance in interorganizational learning (adjusted R^2 of 0.51–0.55). While the levels of significance shift slightly depending upon which interaction term is used, overall the patterns of association displayed by the models are stable. Further, given the large number of independent variables relative to the sample size and the high correlations between some of the independent variables, the potential for multicollinearity was high and regression diagnostics were used. We therefore calculated the square root of variance inflation factor for the independent variables. Their values ranged from 1.09 to 1.56, all within Fox's (1991) acceptable range.

Model 1 uses the interaction term for biochemical knowledge relevance and shared research communities. It had the anticipated negative association with interorganizational learning, and both it and the change in R^2 it produced were significant at $p < 0.05$. The other control, R&D spending by the pharmaceutical firm, has the

expected positive association with interorganizational learning, but only weakly ($p < 0.10$). The independent variables measuring the first dimension of relative absorptive capacity, valuing a specific teacher firm's knowledge, produce mixed results in this model. The relevance of the student firm's basic knowledge (biochemistry) is positively related to interorganizational learning ($p < 0.01$), thus supporting Hypothesis 1. However, the relevance of the student firm's specialized (nonbiochemical) knowledge is not significant and offers no support for Hypothesis 2.

The variables associated with the second dimension of relative absorptive capacity, assimilating new knowledge from a specific teacher firm, show mixed support for Hypothesis 3. This hypothesis predicts that the more similar the alliance partners' organizational structures, the more interorganizational learning. Of the four measures of organizational structure similarity used, only two showed the predicted positive association: similarity of lower management formalization ($p < 0.001$) and similarity of research centralization ($p < 0.10$). The two other measures of structure similarity—upper management formalization and management decision centralization—have significant *negative* associations with interorganizational learning (both at $p < 0.001$). The results for the other hypothesis regarding knowledge assimilation, Hypothesis 4, were less ambiguous. Its prediction that the similarity of alliance partners' compensation practices will also be positively related to interorganizational learning was strongly supported ($p < 0.01$).

In light of the mixed results concerning struc-

Table 2. Results of regression analyses for interorganizational learning index

Variables	Model 1 β	Model 2 β	Model 3 β
Control			
Pharmaceutical firm R&D/sales	0.29†	0.32†	0.22
Valuing new knowledge			
Relevance of biochemical knowledge	0.38*	0.22*	0.51*
Relevance of nonbiochemical knowledge	−0.22	−0.14	0.26
Assimilating new knowledge			
Similarity of upper management formalization	−0.53***	−0.55***	−0.52***
Similarity of lower management formalization	0.68***	0.71***	0.68***
Similarity of management centralization	−0.64***	−0.66***	−0.64***
Similarity of research centralization	0.28†	0.35*	0.26†
Similarity of compensation practices	0.43**	0.47**	0.44*
Commercializing new knowledge			
Number of shared research communities	0.83**	0.86**	0.45*
Knowledge and research interactions			
Biochemical knowledge relevance × shared research communities	−0.65*		
Nonbiochemical knowledge relevance × shared research communities		−0.66*	
Biochemical knowledge relevance × nonbiochemical knowledge relevance			−0.85*
R^2	0.70	0.67	0.69
Adj. R^2	0.55	0.51	0.54
F	4.69***	4.13**	4.47**
Change in R^2	0.095*	0.067*	0.085*

$N = 31$ for all models
† $= p < 0.10$; * $= p < 0.05$; ** $= p < 0.01$; *** $= p < 0.001$

ture similarity and interorganizational learning, we reexamined our data to see if those results may be a function of the basic differences of the two sets of firms which formed the alliances. The pharmaceutical firms are far larger than the biotechnology firms and thus may need more formalized upper management and more centralized management systems. This interpretation is supported by the fact that pharmaceutical firms on average report significantly more formal upper management practices ($t = 2.67$, $p < 0.05$) and centralization of management decisions ($t = 1.70$, $p < 0.10$) than biotechnology firms. However, pharmaceutical firms also tend to report significantly more formalized lower management practices than biotechnology companies ($t = 2.27$, $p < 0.05$). If the mixed results for Hypothesis 3 were due to structural differences between the two populations of firms, there should be no meaningful difference in their mean levels of

lower management formalization. Thus, we concluded that the mixed results were not an artifact of the two types of firms that formed the alliances.

The variable associated with the third dimension of relative absorptive capacity, the ability to commercialize knowledge from a specific teacher firm, shows strong support for Hypothesis 5. The number of research communities shared by the partners is positively associated with interorganizational learning ($p < 0.01$).

Model 2 uses a different interaction term—nonbiochemical knowledge relevance and shared research communities—but produces very similar results. This interaction and the other control—R&D spending—have the same signs and levels significance as in Model 1. The association between relevance of nonbiochemical knowledge and interorganizational learning remains positive and significant at $p < 0.05$. The organizational

structure variables exhibit the same mixed results, with the only difference being that research centralization is slightly more significant ($p < 0.05$). The direction and significance of the associations for compensation practices and shared research communities are also unchanged.

Model 3 uses the final interaction term (biochemical knowledge relevance and nonbiochemical knowledge relevance). Again, both the interaction term and its change in R^2 were significant at $p < 0.05$. The results of Model 3 do not meaningfully differ from those of Models 1 and 2, with the exception of three decreases in significance. R&D spending is no longer significant, compensation similarity is significant at $p < 0.10$, and shared research communities is significant at $p < 0.05$.

Post hoc analyses

Two additional questions remain: what is the value added to the management literature of our three-dimensional construct of relative absorptive capacity; and which of the three dimensions is most important for promoting interorganizational learning? Regarding the first question, recall that we included R&D spending in our model because Cohen and Levinthal used it as a proxy for absorptive capacity, and therefore it represents a benchmark against which all other measures of that construct should be judged. Also recall that their measure of absorptive capacity is a firm-level proxy for the student's absolute absorptive capacity, while we argue for a dyad-level, relative construct. Regarding the second question, Cohen and Levinthal view the role of prior relevant technological knowledge as paramount and discuss the role of knowledge-processing systems only in terms of internal communication for sharing knowledge. Absent from their theory, but central to ours, is the argument that valuable knowledge tends to be embedded in specific knowledge-processing systems (Leonard-Barton, 1992; Teece and Pisano, 1994; Spender, 1996).

With these distinctions in mind, we ran a hierarchical regression analysis (see Table 3). We entered three blocks of explanatory variables into the model based on their conceptual proximity to prior absorptive capacity research. Specifically, we entered R&D spending first. Consistent with the results we reported in Table 1, we found that R&D explained only 4 percent of the variance in

the dependent variable—interorganizational learning. Next, we added the three bibliometric-based measures of knowledge similarity (basic knowledge, specialized knowledge, and shared research communities). We also included a fourth variable in this block—an index of the three highly correlated interaction terms. This second block of variables made a significant contribution to the model ($p < 0.05$) by explaining an additional 17 percent of the variance. Finally, we added the five knowledge-processing similarity variables (the variables having to do with formalization, centralization, and compensation). This last block made a highly significant ($p < 0.001$) contribution to the model by explaining an additional 55 percent of the variance in interorganizational learning.

This analysis suggests that the absorptive capacity of student firms in learning alliances appears to be inherently relative and therefore best measured at a dyadic unit of analysis. The similarities in 'know-what' (knowledge), 'know-how' (knowledge-processing systems), and 'know-why' (dominant logics) turn out to be more important to interorganizational learning than the commonly used measure of absolute absorptive capacity. Thus, the ability of a firm to learn from another firm is jointly determined by the relative characteristics of the two firms, particularly the relationship between their knowledge-processing systems. Furthermore, the low explanatory power of R&D spending calls into question the usefulness of this coarse-grained, absolute measure of absorptive capacity.

DISCUSSION AND CONCLUSIONS

Firms are increasingly relying on knowledge acquired from other firms to facilitate the development of their own capabilities. To deepen our understanding of that process, this study examined the role that partner characteristics play in the success of interorganizational learning. We reconceptualized Cohen and Levinthal's firm-level construct—absorptive capacity—as a learning dyad construct, *relative* absorptive capacity, that is jointly determined by three characteristics of the student and teacher firms. We then argued that the relative similarity of those characteristics affects the student's ability to value, assimilate, and commercialize its teacher's knowledge. Using a sample of alliances between pharmaceutical

Table 3.   Contribution of relative absorptive capacity measures: Results of hierarchical regression analysis

Variable blocks	Interorganizational learning index ΔR^2
1. *Cohen and Levinthal's (1990) measure*	
Pharmaceutical firm R&D/sales	0.03†
2. *Knowledge and research similarities*	0.14*
Relevance of biochemical knowledge	
Relevance of nonbiochemical knowledge	
Number of shared research communities	
Biochemical knowledge relevance × shared research communities	
3. *Social context similarities*	0.53***
Similarity of upper management formalization	
Similarity of lower management formalization	
Similarity of management decision centralization	
Similarity of research decision centralization	
Similarity of compensation practices	
R^2	0.70
Adj. R^2	0.55
F	4.69***

$N = 31$ for all models
†$p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

firms (the students) and biotechnology firms (the teachers), we tested our hypotheses after controlling for Cohen and Levinthal's absolute measure of absorptive capacity (R&D/sales) and for too much knowledge similarity (the interaction terms). Our dependent variable, interorganizational learning, was derived from a card-sorting exercise using industry experts. Our independent variables were derived from bibliometric data, a survey instrument mailed to HRM executives in each alliance partner, and secondary data. We found support for Hypothesis 1 (relevance of basic knowledge), Hypothesis 4 (compensation practices similarity), and Hypothesis 5 (shared research communities), partial support for Hypothesis 3 (knowledge-processing systems), but not support for Hypothesis 2 (specialized knowledge).

While our findings are based on 45 percent of the population of medical alliances between pharmaceutical and biotechnology firms in effect as of November 1993, they may generalize to a variety of other collaborations involving knowledge transfer. These include other interorganizational alliances such as consortia, university–corporate partnerships, acquisitions, and joint ventures. The knowledge transfers also include *intra*organizational linkages such as those intended to leverage a firm's 'core competence' across its business units, especially in complex, transnational corporations (Bartlett and Ghoshal, 1995). Finally, the concept of relative absorptive capacity may also help explain other, less beneficial, forms of interorganizational learning such as mimetic isomorphism (DiMaggio and Powell, 1983). Simply put, while imitating one's peers may not always be an effective course of action, the high level of relative absorptive capacity a firm will tend to have with its peers may make them the most easily understood teachers.

Finally, our findings suggest that a firm devote at least as much attention to managing its capabilities as it does to managing its physical assets. As competition becomes more knowledge-based, a firm must develop a thorough understanding of its own knowledge, the processes by which it converts knowledge to capabilities, and the capacity of those capabilities to meet the demands of its environment. Without this level of self-awareness, a firm will be slow to react to the market forces that inevitably erode the combined strategic value of its set of capabilities. It will

have difficulty developing effective new capabilities on its own, and lack the clear criteria needed to identify the best-qualified 'teachers'.

ACKNOWLEDGEMENTS

REFERENCES

Alexander, J. C. and R. H. Mabry (1994). 'Relative significance of journals, authors, and articles cited in financial research', *Journal of Finance*, **49**, pp. 697–712.

Arora, A. and A. Gambardella (1990). 'Complementary and external linkages: Strategies of the large firm in biotechnology', *Journal of Industrial Economics*, **38**(4), pp. 361–379.

Balkin, D. B. and L. R. Gomez-Mejia (1990). 'Matching compensation and organizational strategies', *Strategic Management Journal*, **11**(2), pp. 153–169.

Barney, J. (1991). 'Firm resources and sustained competitive advantage', *Journal of Management*, **17**(1), pp. 99–120.

Barney, J. B. (1995). 'Looking inside for competitive advantage', *Academy of Management Executive*, **9**(4), pp. 48–61.

Bartlett, C. A. and S. Ghoshal (1995). *Transnational Management* (2nd edn.). Irwin, Chicago, IL.

Bettis, R. and C. K. Prahalad (1995). 'The dominant logic: Retrospective and extension', *Strategic Management Journal*, **16**(1), pp. 5–14.

Borokhovich, K. A., R. J. Bricker and B. J. Simkins (1994). 'Journal communications and influence in financial research', *Journal of Finance*, **49**, pp. 713–725.

Bower, G. H. and E. R. Hilgard (1981). *Theories of Learning*. Prentice-Hall, Englewood Cliffs, NJ.

Burns, T. and G. Stalker (1961). *The Management of Innovation*. Tavistock, London.

Child, J. (1984). *Organization: A Guide to Problems and Practice* (2nd edn.). Harper & Row, London.

Chung, K. H. and R. A. K. Cox (1990). 'Patterns of productivity in the finance literature: A study of bibliometric distributions', *Journal of Finance*, **45**, pp. 301–309.

Cohen, W. M. and D. A. Levinthal (1989). 'Innovation and learning: Two faces of R&D', *Economic Journal*, **99**, pp. 569–596.

Cohen, W. M. and D. A. Levinthal (1990). 'Absorptive capacity: A new perspective on learning and innovation', *Administrative Science Quarterly*, **35**, pp. 128–152.

Cook, F. W. (1981). 'The compensation director and the board's compensation committee', *Compensation and Benefits Review*, **13**, pp. 37–41.

Cox, R. A. K. and K. H. Chung (1991). 'Patterns of research output and author concentration in the economics literature', *Review of Economics and Statistics*, **73**, pp. 740–747.

Daft, R. L. and G. P. Huber (1987). 'How organizations learn: A communication framework', *Research in the Sociology of Organizations*, **5**, pp. 1–36.

D'Aveni, R. A. (1994). *Hypercompetition*. Free Press, New York.

Dierickx, I. and K. Cool (1989). 'Asset stock accumulation and sustainability of competitive advantage', *Management Science*, **35**, pp. 1504–1511.

Dillman, D. A. (1978). *Mail and Telephone Surveys: The Total Design Method*. Wiley, New York.

DiMaggio, P. J. and W. W. Powell (1983). 'The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields', *American Sociological Review*, **48**, pp. 147–160.

Ellis, H. C. (1965). *The Transfer of Learning*. Macmillan, New York.

Estes, W. K. (1970). *Learning Theory and Mental Development*. Academic Press, New York.

Fox, J. (1991). *Regression Diagnostics*. Sage, Newbury Park, CA.

Franklin, J. J. and R. Johnston (1988). 'Co-citation bibliometrics as a tool of S&T and R&D management: Issues, applications, and developments'. In A. F. J. Van Raan (ed.), *The Handbook of Quantitative Studies of Science and Technologies*. North-Holland, Amsterdam, pp. 325–389.

Galbraith, C. S. and G. B. Merrill (1991). 'The effect of compensation program and structure on SBU competitive strategy: A study of technology-intensive firms', *Strategic Management Journal*, **12**(5), pp. 353–370.

Gomez-Mejia, L. R. (1992). 'Structure and process of diversification, compensation strategy, and firm performance', *Strategic Management Journal*, **13**(5), pp. 381–397.

Gordon, M. E. and J. E. Purvis (1991). 'Journal publications as a measure of performance in industrial relations', *Industrial and Labor Relations Review*, **45**, pp. 194–201.

Grant, R. M. (1988). 'On "Dominant Logic", relatedness, and the link between diversity and performance', *Strategic Management Journal*, **9**(6), pp. 639–642.

Grant, R. M. and C. Baden-Fuller (1995). 'A knowledge-based theory of inter-firm collaboration', *Academy of Management Best Paper Proceedings*, pp. 17–21.

Guetzkow, H. (1965). 'Communications in organizations'. In J. G. March (ed.), *Handbook of Organizations*. Rand McNally, Chicago, IL, pp. 534–573.

Hamel, G. (1991). 'Competition for competence and inter-partner learning within international strategic alliances', *Strategic Management Journal*, Summer Special Issue, **12**, pp. 83–103.

Hamel, G., Y. Doz and C. K. Prahalad (1989). 'Collaborate with your competitors and win', *Harvard Business Review*, **67**(1), pp. 133–139.

Haspeslagh, P. C. and D. B. Jemison (1991). *Managing Acquisitions: Creating Value through Corporate Renewal*. Free Press, New York.

Healy, P., H. Rothman and P. K. Hock (1986). 'An experiment in science mapping for research planning', *Research Policy*, **15**(5), pp. 233–252.

Hedberg, B. L. T. (1981). 'How organizations learn and unlearn'. In P. C. Nystrom and W. H. Starbuck (eds.), *Handbook of Organizational Design*, Vol. I. Oxford University Press, New York, pp. 3–27.

Henderson, R. M. and I. Cockburn (1994). 'Measuring competence? Exploring firm effects in pharmaceutical research', *Strategic Management Journal*, Winter Special Issue, **15**, pp. 63–84.

Hicks, D. (1987). 'Limitations of co-citation analysis for science policy', *Social Studies of Science*, **17**, pp. 295–316.

Hoskisson, R. E., M. A. Hitt and C. W. Hill (1993). 'Managerial incentives and investment in R&D in large multiproduct firms', *Organization Science*, **4**(2), pp. 325–341.

Huber, G. P. (1991). 'Organizational learning: The contributing processes and literatures', *Organization Science*, **2**(1), pp. 88–115.

Judge, T. A. and G. R. Ferris (1993). 'Social context of performance evaluation decisions', *Academy of Management Journal*, **36**(1), pp. 80–105.

Kerr, J. (1985). 'Diversification strategies and managerial rewards: An empirical study', *Academy of Management Journal*, **28**, pp. 155–179.

Kerr, J. L. and J. W. Slocum (1987). 'Managing corporate cultures through reward systems', *Academy of Management Executive*, **1**(2), pp. 3–15.

Klavans, R. (1994). 'The measurement of a competitor's core competence'. In G. Hamel and A. Heene (eds.), *Competence-based Competition*. Wiley, New York, pp. 171–182.

Kogut, B. (1988). 'Joint ventures: Theoretical and empirical perspectives', *Strategic Management Journal*, **9**(4), pp. 319–332.

Lawrence, P. R. and J. Lorsch (1967). *Organization and Environment*. Irwin, Homewood, IL.

Leonard-Barton, D. (1992). 'Core capabilities and core rigidities: A paradox in managing new product development', *Strategic Management Journal*, Summer Special Issue, **13**, pp. 111–125.

Miller, D. (1987). 'Strategy making and structure: Analysis and implications for performance', *Academy of Management Journal*, **30**, pp. 7–32.

Miller, D. and C. Droge (1986). 'Psychological and traditional determinants of structure', *Administrative Science Quarterly*, **31**, pp. 539–560.

Miller, D., C. Droge and J. Toulouse (1988). 'Strategic process and content as mediators between organizational context and structure', *Academy of Management Journal*, **31**, pp. 544–560.

Mombers, C., A. von Heeringer, R. van Venetie and C. le Pair (1985). 'Displaying the strength and weaknesses in national R&D performance through document co-citation', *Scientometrics*, **7**, pp. 341–356.

Nelson, R. and S. Winter (1982). *An Evolutionary Theory of Economic Change*. Harvard University Press, Cambridge, MA.

Nicholls-Nixon, C. (1993). 'Absorptive capacity and technological sourcing: Implications for the responsiveness of established firms', unpublished Ph.D. dissertation, Purdue University.

Park, S. H. and M. E. Gordon (1996). 'Publication records and tenure decisions in the field of strategic management', *Strategic Management Journal*, **17**(2), pp. 109–128.

Pennings, J. M. and F. Harianto (1992a). 'The diffusion of technological innovation in the commercial banking industry', *Strategic Management Journal*, **13**(1), pp. 29–46.

Pennings, J. M. and F. Harianto (1992b). 'Technological networking and innovation implementation', *Organization Science*, **3**, pp. 356–382.

Pisano, G. P. (1994). 'Knowledge, integration, and the locus of learning: An empirical analysis of process development', *Strategic Management Journal*, Winter Special Issue, **15**, pp. 85–100.

Pisano, G. P. and P. Y. Mang (1993). 'Collaborative product development and the market for know-how: Strategies and structures in the biotechnology industry'. In R. A. Burgelman and R. S. Rosenbloom (eds.), *Research on Technological Innovation Management and Policy*, Vol. 5. JAI Press, Greenwich, CT, pp. 109–136.

Prahalad, C. K. and R. Bettis (1986). 'The dominant logic: A new linkage between diversity and performance', *Strategic Management Journal*, **7**(6), pp. 485–501.

Prahalad, C. K. and G. Hamel (1990). 'The core competence of the corporation', *Harvard Business Review*, **68**(3), pp. 71–91.

Pritchard, A. (1969). 'Statistical bibliography or bibliometrics?', *Journal of Documentation*, **25**, pp. 348–350.

Quinn, D. P. and P. Rivoli (1991). 'The effects of American- and Japanese-style employment and compensation practices on innovation', *Organization Science*, **2**(4), pp. 323–341.

Rappaport, A. (1986). *Creating Shareholder Value*. Free Press, New York.

Salter, M. S. (1973). 'Tailor incentive compensation to strategy', *Harvard Business Review*, **51**(2), pp. 94–102.

Schein, E. (1985). *Organizational Culture and Leadership*. Jossey Bass, San Francisco, CA.

Shan, W., G. Walker and B. Kogut (1994). 'Interfirm cooperation and startup innovation in the biotechnology industry', *Strategic Management Journal*, **15**(5), pp. 387–394.

Spender, J.-C. (1989). *Industry Recipes: An Inquiry into the Nature and Sources of Managerial Judgment*. Blackwell, Oxford, UK.

Spender, J.-C. (1996). 'Competitive advantage from

tacit knowledge? Unpacking the concept and its strategic implications'. In B. Moingeon and A. Edmondson (eds.), *Organizational Learning and Competitive Advantage*. Sage, Newbury Park, CA.

Teece, D. and G. Pisano (1994). 'The dynamic capabilities of firms: An introduction', *Industrial and Corporate Change*, **3**(3), pp. 537–556.

Thompson, J. D. (1967). *Organizations in Action*. McGraw-Hill, New York.

Tosi, H. L. and L. R. Gomez-Mejia (1989). 'The decoupling of CEO pay and performance: An agency theory perspective', *Administrative Science Quarterly*, **34**, pp. 169–190.

Tushman, M. and P. Anderson (1986). 'Technological discontinuities and organizational environments', *Administrative Science Quarterly*, **31**, pp. 439–465.

Tushman, M. and D. A. Nadler (1978). 'Information processing as an integration concept in organization design', *Academy of Management Review*, **3**, pp. 613–624.

Vijver, F. and W. J. Lonner (1995). 'A bibliometric analysis of the *Journal of Cross-cultural Psychology*', *Journal of Cross-cultural Psychology*, **26**, pp. 591–602.

Walsh, J. P. and G. R. Ungson (1991). 'Organizational memory', *Academy of Management Review*, **16**(1), pp. 57–91.

Weber, C. L. and S. L. Rynes (1991). 'Effects of compensation strategy on pay decisions', *Academy of Management Journal*, **34**, pp. 86–109.

Zajac, E. J. (1990). 'CEO selection, succession, compensation and firm performance: A theoretical integration and empirical analysis', *Strategic Management Journal*, **11**(3), pp. 217–230.

Zolo, D. (1989). *Reflexive Epistemology: The Philosophical Legacy of Otto Neurath*. Kluwer, Boston, MA.