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THE GLOBAL ACQUISITION, LEVERAGE, AND PROTECTION OF TECHNOLOGICAL COMPETENCIES

SUSAN K. McEVILY,[1] KATHLEEN M. EISENHARDT[2] and JOHN E. PRESCOTT[1]*
[1] *Katz Graduate School of Business, University of Pittsburgh, Pittsburgh, Pennsylvania, U.S.A.*
[2] *Department of Management Science and Engineering, Stanford University, Stanford, California, U.S.A.*

How managers acquire, leverage, and protect technological *competencies in order to innovate successfully and enhance firm performance is central to the field of strategic management. When tensions across acquisition, leverage, and protection activities are resolved and synergies are captured, the value derived from technological competencies can be used to fuel a virtuous cycle in which fewer resources are needed to perpetuate a firm's advantage. The papers in this issue examine the mechanisms underlying acquisition, leverage, and protection, and are particularly useful in resolving these tensions and highlighting potential synergies. We develop a typology to describe the research domain and relate these papers to one another. Based on gaps in this typology and issues raised by these papers, we offer observations for future research on the acquisition, leverage, and protection of technological competencies.* Copyright © 2004 John Wiley & Sons, Ltd.

Technological innovation is crucial to a variety of important outcomes, including economic growth, firm performance, and industrial change. Hence, the ability to effectively innovate is a central challenge for firms. Firms with superior technological competencies (i.e., the ability to apply scientific and technical knowledge to develop and improve products and processes) tend to be more innovative and thus perform at higher levels. The papers in this special issue examine how managers of firms *acquire, leverage, and protect* technological competencies in order to innovate successfully and enhance the performance of their firms. Innovation is treated broadly, encompassing the production of new knowledge and novel products. The focus on acquisition, leverage, and protection processes emanates from themes in the strategic management, organizational theory, and economic literatures.

Resource-based, dynamic capability, and knowledge-based theories of the firm explain how competencies, such as those supporting technological innovation, create competitive advantage. However, they emphasize different underlying dynamics. Resource-based theory proposes that the deployment and *protection* of unique knowledge underlies sustained competitive advantage (Barney, 1991). The dynamic capabilities view emphasizes that competencies need to change over time in order to maintain their value. Thus, it highlights knowledge development and capabilities *acquisition* as crucial processes (Teece, Pisano, and Shuen, 1997; Eisenhardt and Martin, 2000). The knowledge-based view of the firm identifies *leveraging* through the integration (Grant, 1996), transfer or replication (Kogut and Zander, 1992), and recombination (Galunic and Rodan, 1998) of competencies as central to competitive advantage.

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*Correspondence to: John E. Prescott, Katz Graduate School of Business, University of Pittsburgh, 246 Mervis Hall, Pittsburgh, PA 15260, U.S.A. E-mail: prescott@katz.pitt.edu

While each of the theoretical approaches emphasizes a particular aspect of how competencies provide value, strategic managers typically choose among acquisition, leveraging and protection activities. Given the distinctive character of each activity, a fundamental question is whether managers should develop strategies that focus on one activity, such as acquisition, or whether they should attempt to blend activities despite apparent tradeoffs among them.

On the one hand, previous research highlights tensions between the three processes (Teece, 1998). Knowledge that flows easily across organizational boundaries, and is therefore less costly to acquire and leverage, is also easier for competitors to imitate, and thus more costly to protect (Kogut and Zander, 1992). Further, structuring competencies so as to facilitate transfer and recombination, such as by codifying or 'modularizing' knowledge, may erode their ability to create a sustainable advantage (Rivkin, 2001). On the other hand, the three processes may actually be complementary. That is, firms may develop competencies simultaneously across the three activities by managing them in a complementary fashion. For instance, investments made to leverage competencies may also help to protect them if the two activities use common inputs or contribute to complementary dynamics. When synergies across the three activities are captured, the value derived from technological competencies can be used to fuel a virtuous cycle in which fewer resources are needed to perpetuate a firm's advantage. Since the papers in this issue examine the mechanisms underlying acquisition, leverage, and protection, they are particularly useful in resolving these tensions and in highlighting potential synergies.

We adopt the terms 'acquisition', 'leverage,' and 'protection' to refer broadly to the distinctive types of activities that can engender competitive advantage from technological competencies. *Acquisition* is the process by which firms develop new scientific and technological competencies, and renew old ones. This includes acquiring other organizations or collaborating with them to gain access to new technologies. It also encompasses the assimilation or absorption of technological knowledge from other organizations or public sources and the creation of technological competence through search, experimentation, and other learning processes. *Leverage* refers to how firms extract value from existing technological competencies. It encompasses the transfer of knowledge or capabilities to different organizational units, new product or geographic markets, and the exploitation, integration, and recombination of extant competencies. *Protection* is the process by which firms sustain the uniqueness and value of their technological competencies. Firms protect their technological competencies using a variety of mechanisms, including: legal property rights, secrecy, retention of key employees, partitioning work (structural isolation), counterintelligence, and strategically sharing information. Technological competencies may also be protected by their complexity, specificity, and tacitness, characteristics of the accumulation process, and barriers to interorganizational learning (e.g., heterogeneous resources).

We begin this essay with a characterization of the submissions to the special issue, and several broad themes. We then briefly outline each of the articles within the special issue, highlighting their research questions, methods, and central insights. We close with two observations that emerge from this collection of papers.

OVERVIEW OF THE SPECIAL ISSUE

The widespread research interest in technological competencies is reflected in the number and quality of submissions to this special issue. Approximately 120 papers that varied widely in topics and methods were submitted. Fifty-eight papers (48%) addressed leveraging technological competencies, 41 (34%) examined aspects of acquisition processes, and 16 (13%) dealt with protecting competencies. Only a few (5%) did not fit the focus of the special issue.

Most of the submitted papers examining leverage explored how organizations (23) or collaboration through alliances or consortia (19) affect a firm's ability to leverage its technological competencies. About 13 of these papers explored how a firm's diversification, global strategy, or technological strategy shaped its approach to competence leverage, while nine specifically addressed geographic or national influences on leveraging outcomes. Fourteen of the papers submitted on the acquisition of competences investigated country influences, 10 examined organizational influences, nine investigated acquisition in the context

of alliances, six explored other kinds of external sources, five examined the influence of strategy on acquisition, and one explored acquisitions to gain competencies. Most of the submitted papers on protection investigated the use of patents to sustain the value of technological competencies. An interesting exception was a paper that examined rapid innovation as a protective mechanism. Finally, while most of the submitted papers on competence acquisition were empirical, the papers on leverage and protection tended to be more theoretical.

In terms of accepted papers, there is variety in their focus. About half of them examine choices (e.g., location of R&D, attempts to transfer competencies, scope and structure of contracts) that indicate the underlying logic behind efforts to acquire, leverage, or protect competencies. The other half focuses on performance outcomes in order to enhance understanding of the effectiveness of various practices or strategies in acquiring or leveraging technological competencies. We have organized the papers into four sets central to the nexus of the acquisition, leverage, and protection of technological competencies: across firm issues, within firm issues, contextual factors, and search processes.

The first two papers in this issue examine *key dilemmas in alliances and acquisitions*, primary means of acquiring technological competence. Research on alliances has explored the rationales and mechanisms that make them effective vehicles for learning and innovation, and identified the degree of knowledge overlap among partners as an important precursor to competence transfer (Mowery, Oxley, and Silverman, 1996; Lane and Lubatkin, 1998). Significantly, less attention has been given to how firms can protect their technological competencies at the same time they collaborate with other organizations. Oxley and Sampson examine this tension between sharing and protecting technology in alliances, and identify specific mechanisms firms can use to balance these goals.

Acquisitions represent an alternative approach to alliances for obtaining technological competencies. Here the challenge is to actually gain the expected value of acquired competencies. Ample evidence indicates that managers often fail to realize value from acquisitions, and implicates cultural and organizational barriers. A few studies (Ahuja and Katila, 2001; Puranam, Singh, and Zollo, 2003) have tackled the task of explaining how firms can successfully leverage acquired technological knowledge to sustain their innovation performance. In a creative field-based study, Graebner breaks down post-acquisition performance further and reveals how managers can capture expected and unexpected value from acquired technological competencies.

An issue worthy of attention is how the competence acquisition objectives affect the processes used to assimilate them. Alliances and acquisitions are touted as vehicles for both exploratory and exploitative learning (Mowery *et al*., 1996; Ahuja and Katila, 2001; Puranam *et al*., 2003). But researchers have only begun to examine how the type of learning goal affects the desired attributes of a partner or target, and how collaboration and integration processes are managed. For instance, exploration implies less knowledge overlap between firms, but it is not clear how this affects competence acquisition processes. Oxley and Sampson, and Graebner suggest that contractual relations and managerial actions need to correspond to the competence acquisition goals. In addition, most technology-based acquisitions seek knowledge that resides within people, suggesting that competence acquisition requires changing communication patterns. Studies that examine the evolving structure of interpersonal networks could reveal how to transform and develop new competencies through alliances and acquisitions.

Two papers deal with leveraging technological competences through *competence transfer within firms*. Previous research (Szulanski, 1996) has suggested that knowledge overlap between the source and recipient affects the ease with which a technology or best practice is assimilated by a new organizational unit. In an intriguing extension, Nerkar and Roberts examine the influence of knowledge overlap on leveraging competencies into new products. They investigate how the competencies acquired to support a particular product interact with a firm's experience in other technologies and markets to affect the success of its new product launches. Leveraging technological competence into new products is at the heart of why companies cultivate these resources; yet, studies examining product outcomes are rare. Gaps in a recipient's knowledge stem from physical and social distance from the source and differences in technical skills. In this regard, Hansen and Lovas investigate the degree to which formal and informal relationships enable firms to overcome

the barriers created by geographic, cultural, and technological distance. Knowing which policies and resources complement or substitute for each other is central to effectively leveraging technological competencies, especially in complex organizations such as diversified multinational corporations (MNCs).

The list of factors that influence the ease of knowledge transfer is long, and includes technological, geographic, and cultural proximity (Gupta and Govindarajan, 2000), knowledge attributes (Szulanski, 1996), status of the source (Thomas-Hunt, Ogden, and Neale, 2003), and the capabilities and motivation of the recipient (Tsai, 2001). Research has also identified many tools for overcoming these barriers, such as the use of rich communications media (Gupta and Govindarajan, 2000), the cultivation of certain kinds of relationships among employees (Hansen, 1999; Reagans and McEvily, 2003), and development of information technologies and organization structures to lower coordination and communication costs and create opportunities for exchange (Argote, McEvily, and Reagans, 2003). However, few studies have examined interactions between these mechanisms or identified which barriers they are most effective in circumventing or lowering. In addition, most research on transfer adopts some measure of effective transfer as the outcome. It would be useful to take this one step further and link effective transfer to other performance outcomes such as innovation, survival, and profitability.

Three papers examine how *country and corporate context* affect competence acquisition and leverage. Feinberg and Gupta investigate how opportunities to acquire (via knowledge spillovers), and the ability to protect (through ownership) and leverage (i.e., transfer to other subsidiaries) technological competencies affect an MNC's decision to locate research and development with a particular foreign subsidiary. The other two studies offer evidence that country context does affect a firm's innovativeness, but that characteristics of the MNC also matter. Almeida and Phene demonstrate how attributes of the host country and MNC influence the subsidiary's innovativeness. Thomas reveals how the mix of country locations in which a firm has operations, as compared to breadth of product market scope, influences innovation outcomes. Collectively, these papers highlight the importance of location for acquiring and leveraging technological competencies, and indicate that corporate strategy and structure moderate the influence of country effects. In general, the role of geography in strategy is under-researched, and the direct and indirect effects of geography in the acquisition, leverage, and protection of technological competencies is a particularly fertile area for research.

Finally, three papers offer new insights into *search processes* that underlie the acquisition of technological competencies. Exploratory search is useful for developing new competencies, but there is often substantial pressure to exploit existing competencies (March, 1991). Although recent studies emphasize the value of diverse perspectives for exploration (Rosenkopf and Nerkar, 2001), there is little evidence to suggest how the search for new technological competencies unfolds. These papers extend the literature by exploring the antecedents of search behavior and its role in competence acquisition. Ahuja and Katila investigate *when* firms embark on a new search trajectory; they identify triggers for firms to change their search patterns. Argyres and Silverman examine *where* firms look for technological knowledge, and reveal organizational drivers of the breadth of search. Fleming and Sorenson discuss *how* firms use science to search for novel and effective technological solutions. These authors offer complementary perspectives on how managers can guide search and problem solving to encourage the acquisition of valuable technological competencies.

The latter two sets of papers raise questions about how managers should shape the knowledge flows across organizational, geographic, and technological boundaries. Exposure to diverse perspectives often spurs creativity and yields superior ideas (Amabile, 1988; Simon, 1985). However, the value of diversity for innovation seems to depend on the knowledge source (Almeida and Phene). Also, the ability to leverage technological competencies (Feinberg and Gupta) and the kinds of problems encountered (Ahuja and Katila) may influence where the search for knowledge occurs. The value of external knowledge also depends on the kinds of problems to which it is applied (Fleming and Sorenson), and the country and organizational context influence problem selection (Thomas; Argyres and Silverman). Additional research on how diversity influences competence acquisition and leverage, and specifically on how the source of knowledge affects these processes,

would be useful. It is likely that firms develop distinctive competencies for leveraging, which then drive their efforts to acquire additional knowledge. Understanding these structural relationships would enable better identification of complementary leverage and acquisition processes, and better understanding of these processes is shaped by firm context. We turn now to a brief description of each paper within the special issue.

SPECIAL ISSUE PAPERS

Oxley and Sampson examine tensions between leveraging technological competencies and protecting them, in the context of international R&D alliances in the electronic and telecommunication industries. A firm's performance and survival in this industry hinge upon its ability to create and commercialize new technologies; alliances are widely used for this purpose. The authors use a large database to create a sample of 208 R&D alliances among firms headquartered in more than 20 different countries, and they gather patent information for each of the firms involved. A key challenge in using alliances to acquire and leverage technological competencies is the need to protect knowledge at the same time it is exchanged among partners. Oxley and Sampson argue that the scope of an alliance is a crucial lever for managing this tension. They find that firms collaborate on fewer activities when the risks of knowledge spillovers are higher (e.g., when there is greater market overlap among partners, when alliance partners are technological leaders). They also advance the position that scope and governance structure are alternate mechanisms for guarding against knowledge leakage. Firms can either protect their knowledge by aligning incentives, as evidenced by firms' greater reliance on equity joint ventures for broad alliances, or by limiting the number of activities in which they collaborate. Very broad alliances tend to involve technology laggards based in the same country.

Graebner uses multiple case studies and grounded theory-building techniques to reveal how firms can capture the value of technology acquisitions. She investigates eight acquisitions of privately held technology ventures in the communication and information technology industry and finds that acquired managers not only play a crucial role in achieving the intended acquisition goals ('expected value'), but also in realizing unexpected ('serendipitous') value. A key challenge in successful implementation is helping employees cope with the emotional and task-related components of change, and managing the potential conflict between autonomy and integration. Her study uncovers specific types of actions (e.g., mobilizing and mitigating) that managers can take to help employees cope with change, rather than isolating them from it (e.g., focusing, pacing). In this way, acquired managers balance autonomy—which supports exploitation of existing technology, with integration—which promotes exploration through the recombination of technology resources. Both kinds of learning are required to achieve planned synergies, and successfully implement an acquisition. Graebner uses multiple performance measures: revenues derived from acquired technologies, retention of key acquired employees, and managers' perceptions of acquisition performance.

Nerkar and Roberts shed new light on competence leverage. They combine patent and product data for a large sample of firms in the pharmaceutical industry, and investigate how prior technological and market experience affects the success (initial sales) of new products. The authors refer to a firm's knowledge as being 'proximal' if it was acquired in the same market or technological domain as a focal product and 'distal' otherwise. Whereas distal market experience leads to higher initial product sales, it is proximal technological experiences that explain new product success. However, for generic products only market experience matters. The authors also find that the more distal technological experience a firm has, the less able it is to effectively leverage proximal knowledge into new products. On the other hand, distal market experience has a positive effect on a firm's efforts to leverage its technology experience into new products. The authors' attention to new product success is critical, as this is the ultimate reason firms develop technological competencies. The paper raises interesting questions about the role of proximal and distal experience in product innovation, and how the resources firms acquire in the distinctive domains support competence leverage.

Hansen and Lovas examine competence transfers, a key process in leveraging technological

competencies, within a large multinational corporation that manufactures electronics and computing products. Using survey and interview data, the authors investigate competence transfers across 121 projects and among 27 subsidiaries. They find that transfers are more likely among subsidiaries that are geographically and technologically close, and between units already linked by formal and informal relationships. However, their primary goal is to examine the complex relationships between these processes, and this yields some surprising results. Formal and informal relationships are differentially effective in overcoming the negative effects of spatial distance and technological relatedness seems to be less influential than prior research would indicate. Their findings indicate that managers need to understand the interpersonal and social dynamics within their organization to effectively guide competence transfers and assure a firm realizes valuable opportunities to leverage its technology.

Using a large sample of U.S.-based MNCs and their foreign affiliates, Feinberg and Gupta examine the decision to locate R&D responsibilities abroad. Feinberg and Gupta show that potential access to knowledge spillovers in another country leads a firm to locate R&D responsibilities there. They also find that an MNC is much more inclined to locate R&D with a subsidiary if it can protect the resulting technological knowledge and leverage it via a global network of subsidiaries. This is evidenced by a higher probability of locating R&D in subsidiaries in which an MNC has a larger ownership stake, and that engage in a greater volume of cross boarder trade with other subsidiaries. The paper makes an interesting contribution to the literature by developing the concept of local and global knowledge utilization capacity in MNCs.

In contrast, Almeida and Phene explore *a subsidiary's* capabilities for exploiting host country and MNC knowledge. Using patent and patent citation data for semiconductor firms, Almeida and Phene investigate how subsidiary innovativeness is shaped by characteristics (diversity and richness) of the technological knowledge available to it within the host country and within the MNC. A subsidiary's knowledge linkages to other firms in the host country improve its innovative capability. Interestingly, the authors find that technological diversity and technological richness play different roles in subsidiary innovativeness, according to whether the knowledge resides in the host country or the MNC. Specifically, it is the technological richness of the MNC but technological diversity of the host country that positively affect subsidiary innovation. However, there is a difference in subsidiaries' abilities to acquire and leverage knowledge from the host country and MNC. Leading innovators, i.e., subsidiaries with established innovation capabilities, make better use of host country knowledge richness and diversity, but do not have an advantage in exploiting MNC knowledge.

Thomas uses 20 years of product data for 62 Japanese pharmaceutical manufacturers to investigate how local and foreign country experience and product market scope influence innovative capability. Japan, the local context, underwent substantial change around 1981 such that the post-1981 environment favored the production of minor pharmaceuticals (less technologically novel, therapeutics for lesser ailments such as athlete's foot). Thomas categorizes these firms' product launches into 13 different countries as globally important (those sold in six or more foreign nations) and trivial (those sold in five or fewer countries) drugs. He finds that the more socially proximate (i.e., characterized by similar demand, pricing, regulation, prescription practices) foreign experience a firm has, the better able it is to overcome the innovation inhibiting post-1981 conditions in the home country. Firms that acquired more pre-1981 experience in the local context, Japan, and the socially proximate markets of southern Europe were more likely to continue innovating globally important drugs. Firms that entered the Japanese market after 1981 produced only trivial products. On the other hand, diversification exacerbated the effects of the post-1981 local context; diversified firms produced more trivial products, especially when they lack experience in pre-1981 Japan and other proximate markets. Thomas's study shows that technological competencies are shaped by a firm's history of participating in local and foreign market contexts.

Finally, several papers deal with when and where firms search for new knowledge, examining the role of science, geography, and organization on the direction and efficacy of search. Ahuja and Katila distinguish 'path-creating search' (knowledge acquisition from new scientific and geographic areas) from 'path-deepening search' (the acquisition of additional knowledge from the same domains). They maintain that heterogeneity in technological competencies arises from

path-creating search. Using the patenting activities of the largest U.S.-based chemical manufacturers from 1979 through 1992, they examine forces that trigger this kind of search and its influence on a firm's innovativeness (patent output). Ahuja and Katila use patent and non-patent references to assess characteristics of a firm's search for knowledge. The authors find that technological exhaustion prompts firms to rely more heavily on science, and that a change in a firm's international market presence leads it to search for knowledge in a different set of countries. New search patterns lag the change in a firm's situation by 1–3 years in the case of technological exhaustion and by 4 years in the case of geographic market scope. Further, firms that use science intensively and search across countries to a moderate degree generate more patents. In addition to revealing a novel source of heterogeneity in technological competencies, the paper offers new insights into how firms can balance the need for exploitative and exploratory search in order to maintain the value of their technological competencies.

Fleming and Sorenson take a closer look at how science can be used to support innovation. They ask when science is most instrumental for solving technological problems and augmenting the value of innovations (i.e., generating more highly cited patents). They use references to science on a sample of over 16,000 patents to examine inventors' search for knowledge. The authors show that, in addition to eliminating less promising research approaches, science leads inventors more directly to useful combinations of technologies and motivates them to continue searching a technological domain in the face of negative feedback. These benefits are greatest when innovation involves the use of highly coupled technological components. The results of this study are particularly important given the high costs of using science. Firms that apply science to problems where it has the greatest pay-off may acquire more valuable technological competencies (more valuable patents).

Argyres and Silverman ask how the organization of R&D affects the breadth of a firm's search for technological knowledge and the value of its patents. They address these questions using a sample of 71 large, mostly diversified corporations that responded to a 1994 IRI survey on research and development activities. The authors collected financial and patent data for these firms, and use citations to assess a firm's search patterns. Argyres and Silverman find that the centralization of decision-making authority increases the breadth of a firm's search across organizational boundaries, but not across technological domains. Centralization of decision-making authority also increases the technological impact of a firm's patents; however, the advantage of centralization seems to stem primarily from advantages over hybrid organizations. Fully decentralized R&D organizations generate higher-impact innovations than hybrid forms that are only slightly more centralized in decision-making authority. A similar relationship exists between centralization of corporate funding and innovation impact. Further, interactions between decision-making authority and funding suggest that these are complementary instruments for encouraging high-value patents. Centralizing funding without also centralizing decision-making hurts innovation performance, while increasing both yields higher impact patents. The authors suggest several challenges associated with hybrid modes of organizing research and development, and discuss how research budgets and authority can be used to effectively acquire and leverage technological competencies.

OBSERVATIONS AND FUTURE DIRECTIONS

Reflecting on the insights drawn from this collection of studies, we draw two observations for guiding future research. First, we observe that our original conception of acquisition, leverage, and protection of technological competencies as three independent value chain processes is too simplistic. That is, our original view that these activities occur independently, have distinctive inputs and outputs, and can be managed in isolation does not convey the nuanced interdependencies related to the strategic management of technology. The papers in this volume suggest that many technological activities are difficult to assign clearly to the acquisition, leverage, or protection category. For example, the rapid leveraging of technological competencies into successively innovative products may be as important for appropriating value as is protecting those competencies with patents or employment policies. Similarly, since patents are sometimes used as incentives to force others into cross-licensing agreements, they are not only valuable for protection but also for acquisition.

Further, in some cases the three processes occur simultaneously. For example, competence acquisition and leverage can be difficult to disentangle in situations where firms seek to embed acquired technology into existing products as a means to protect their competitive advantage.

Since our set of papers examines a range of knowledge inputs (scientific, technical, market) and outputs (citations, patents, products), they assisted us in enriching our original typology by adding a second dimension. Table 1 illustrates our modified typology that adds a 'domains of technological competencies' dimension to our original process dimension. We identify three domains that represent a technology industry value chain. Specifically, 'science' attempts to gain phenomenological understanding through the production of knowledge outputs (e.g., scientific articles). 'Research' attempts to apply scientific understanding to solve more practical problems that generate innovations with relatively clear links to marketable products. 'Commercialization' attempts to transform innovations into inventions (i.e., improved or novel products and processes) that come to market. Our original processes (i.e., acquisition, leverage, and protection) can occur across these domains. We classified the papers in the special issue into the relevant cells of Table 1.

Our new classification highlights at least two gaps in the literature. First, research focusing on science is underrepresented, while applied research dominates the focus of our set of papers. Researchers have recognized the growing role of science in industrial R&D; however, the evidence on whether or not science leads to more valuable innovations is conflicting (Gittelman and Kogut, 2003; Fleming and Sorenson, 2004). Studies that investigate how firms can best acquire, leverage, and protect scientific knowledge, in order to gain advantage from their technological competencies, might help to resolve these contradictions. These processes are most likely contingent upon an industry's appropriability regime, technological opportunities (Klevorick *et al*., 1995), as well as country effects.

A second noticeable gap is that protection has received limited empirical research, despite its theoretical and practical import. There are several possible reasons. Often, the conditions necessary for sustained heterogeneity are taken as a starting point for studies of knowledge or competence-based advantage. Measurement difficulty is another explanation. There is substantial evidence that firms do learn from one another (Beckman and Haunschild, 2002), and researchers have documented the diffusion and imitation of specific organizational forms, management practices, and technologies (Rogers, 1995). However, few studies link the degree to which technological competencies are protected to the persistence of performance advantages or their value (for exceptions, see Zander and Kogut, 1995; McEvily and Chakravarthy, 2002). Finally, the wide range of practices that contribute to protection (Appleyard, 1996) makes this a challenging topic for empirical research. As a starting point, it would be useful for studies to determine the degree to which firms deliberately seek to protect their technological competencies.

Our second observation is that, at a broad level, we see a need for research on the complementarities between acquisition, leverage, and protection processes. The papers in this issue offer several examples of complementary relationships between these processes, and between specific business practices. For example, Feinberg and Gupta discuss how technology acquisition decisions may be linked to a firm's ability to leverage and protect new technology. Their study suggests that a firm's approach to each of these processes is

Table 1. Acquiring, leveraging, protecting technological competencies: a technology value chain

	Domains of technological competencies		
Competence management activities	Science (Basic research)	Research (Applied research)	Commercialization (Development)
Acquisition	Fleming and Sorenson, Ahuja and Katila	Argyres and Silverman, Feinberg and Gupta, Almeida and Phene	Thomas, Graebner
Leverage		Hansen and Lovas, Feinberg and Gupta, Almeida and Phene	Nerkar and Roberts, Graebner
Protection		Oxley and Sampson	

likely to be constrained by pre-existing capabilities to undertake the others. Argyres and Silverman examine complementarities between specific practices used to acquire and leverage competencies: the centralization of decision-making authority and funding. Additional research is needed to identify sets of practices that are more valuable when used together. This type of research can also reveal the relative value of different practices for acquisition, leverage or protection, as well as unexpected combined effects. For example, Hansen and Lovas show that personal ties are more important than shared technological knowledge in prompting competence transfers. On the other hand, common technological knowledge exacerbates the negative effect of spatial distance on competence transfer, while informal relations overcome it. Finally, certain practices may be effective substitutes for one another. Oxley and Sampson illustrate how alliance scope and governance mechanisms may alternately be used to safeguard technologies. Further research on substitutes should investigate the simultaneous effects of specific practices on acquisition, leverage, and protection outcomes.

CONCLUSION

Many of the practices and processes investigated in these papers contribute to more than one competence management goal. However, we are a long way from fully understanding the links between acquisition, leverage, and protection and how these processes can be effectively managed together. Future work in this area should be cognizant of the competence domain, as the approach to acquisition, leverage, and protection appears to differ for science, research, and commercialization. In addition, links across these areas need to be considered carefully; some practices will augment multiple competence management activities, while others impose trade-offs across them. The relationships between distinctive approaches to competence acquisition, leverage, and protection and a firm's corporate and global strategies also deserve further attention, as both contexts appear to moderate these processes.

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