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A Capability-Based Framework for Open Innovation: Complementing Absorptive Capacity

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ABSTRACT We merge research into knowledge management, absorptive capacity, and dynamic capabilities to arrive at an integrative perspective, which considers knowledge exploration, retention, and exploitation inside and outside a firm's boundaries. By complementing the concept of absorptive capacity, we advance towards a capability-based framework for open innovation processes. We identify the following six 'knowledge capacities' as a firm's critical capabilities of managing internal and external knowledge in open innovation processes: inventive, absorptive, transformative, connective, innovative, and desorptive capacity. 'Knowledge management capacity' is a dynamic capability, which reconfigures and realigns the knowledge capacities. It refers to a firm's ability to successfully manage its knowledge base over time. The concept may be regarded as a framework for open innovation, as a complement to absorptive capacity, and as a move towards understanding dynamic capabilities for managing knowledge. On this basis, it contributes to explaining interfirm heterogeneity in knowledge and alliance strategies, organizational boundaries, and innovation performance.

INTRODUCTION

Firms across industries increasingly open up their innovation processes (Chesbrough, 2006). Lucent Technologies, for instance, successfully devoted enormous resources to internal research, whereas Cisco Systems acquired a lot of knowledge from external sources (Chesbrough, 2003; Dyer et al., 2004). The two firms competed in the same industry, but they pursued entirely different knowledge processes. Consistent with Chesbrough's (2003) pioneering work, open innovation is defined as 'systematically relying on a firm's . . . capabilities of internally and externally carrying out the major technology management tasks . . . along the innovation process' (Lichtenthaler, 2008, p. 148). Thus, firms build strongly on interorganizational knowledge transactions to extend their internal knowledge bases (Argote et al., 2003; Gulati, 1999). However, knowledge management research is often limited to specific internal knowledge processes, e.g. knowledge creation or exploitation (Grant, 1996; Nonaka, 1994). Integrative

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perspectives, which consider knowledge inside and outside a firm's boundaries, are relatively limited (Chesbrough, 2006; Grant and Baden-Fuller, 2004).

In a similar vein, absorptive capacity is an influential concept, but it focuses on utilizing external knowledge inside the firm (Cohen and Levinthal, 1990; Lane et al., 2006). As such, it neglects other important knowledge processes, e.g. internal knowledge generation, whose synthesis may provide new insights into managing knowledge in open innovation processes (Lane et al., 2006; Zahra and George, 2002). A dynamic and integrative view may deepen our understanding of knowledge strategies, their modification over time, and their effects on innovation performance (Argote et al., 2003; Zahra et al., 2006). In particular, the trend towards open innovation calls into question traditional perspectives on firm boundaries (Chesbrough, 2006; Santos and Eisenhardt, 2005; West, 2008). We therefore develop a framework for examining a firm's ability to manage knowledge in open innovation processes. By considering knowledge exploration, retention, and exploitation inside and outside organizational boundaries, an integrative perspective on dynamically managing a firm's knowledge base is adopted. We identify six 'knowledge capacities', which describe a firm's capabilities of managing different knowledge processes. 'Knowledge management capacity' refers to a dynamic capability, which reconfigures and realigns these knowledge capacities.

This article offers several contributions. First, knowledge management capacity is a step towards a theoretical foundation of open innovation. Based on insights from the variation–selection–retention literature (Campbell, 1960), the framework helps to understand how firms may profit from open innovation processes. In light of high failure rates in open innovation, the capability-based framework contributes to explaining interfirm heterogeneity in economic innovation performance (Chesbrough, 2006). Second, the examination of different knowledge processes complements prior absorptive capacity research, and it deepens our understanding of knowledge management capabilities (Lane et al., 2006). By applying capability-based arguments to organizational boundaries, it underlines the importance of non-efficiency perspectives in boundaries research, which go beyond analysing transaction costs (Santos and Eisenhardt, 2005). Third, this article develops a conceptual framework which may contribute to operationalizing knowledge management theory (Argote et al., 2003). Thus, it provides a basis for future empirical studies to overcome the underemphasis on empirical knowledge management research.

The remainder of this article is structured as follows. In the second section, we present an integrative framework for managing knowledge in the context of open innovation. On this basis, the third section addresses six knowledge capacities, which capture a firm's capabilities of managing critical knowledge processes. Following the original work on absorptive capacity (Cohen and Levinthal, 1990), we concentrate on industrial firms that conduct R&D and leverage technological knowledge in their own products. In the fourth section, we examine knowledge management capacity, which reconfigures and realigns the knowledge capacities. We examine the relation between this dynamic capability and a firm's strategy. We further address the role of organizational and knowledge characteristics in developing knowledge management capacity. In addition, we discuss its relationship with innovation performance based on the concepts of technical and evolutionary fitness. We focus on economic rather than technical innovation performance because technical innovation success per se does not help firms to capture value from

innovation. In the fifth section, implications for research and practice are discussed, and the final section provides a conclusion.

THE FRAMEWORK

According to knowledge management and dynamic capabilities research, knowledge involves know-how and information (Helfat et al., 2007; Kogut and Zander, 1992). Know-how refers to accumulated skills and expertise, whereas information primarily comprises facts that may be codified (Kogut and Zander, 1992; Szulanski, 1996). With regard to a firm's critical knowledge management processes, many authors have distinguished knowledge exploration or creation on the one hand and knowledge exploitation or application on the other, sometimes explicitly mentioning the need for retaining knowledge over time (Argote et al., 2003; Bogner and Bansal, 2007; Nonaka, 1994). In addition, recent work has underscored the possibility of organizing knowledge processes outside a firm's boundaries (Cassiman and Veugelers, 2006; Grant and Baden-Fuller, 2004; Gulati, 1999). In particular, multiple authors have underlined the critical role of combining internal and external knowledge in innovation processes (Andersen and Drejer, 2008; Hargadon and Sutton, 1997; von Hippel, 1988). To arrive at an integrative view of managing knowledge in open innovation, we build on these studies and distinguish internal and external knowledge exploration, retention, and exploitation.

Internal knowledge exploration refers to generating new knowledge inside the firm, e.g. inventions resulting from research (Smith et al., 2005). External knowledge exploration describes the acquisition of knowledge from external sources (Lane et al., 2006). Internal knowledge retention is a result of the need for maintaining knowledge over time (Garud and Nayyar, 1994). External knowledge retention refers to knowledge that is maintained in a firm's interorganizational relationships, e.g. alliances (Gulati, 1999). Internal knowledge exploitation describes internal innovation, i.e. knowledge application in a firm's own products (Brown and Eisenhardt, 1995). External knowledge exploitation refers to outward knowledge transfer, e.g. by means of technology alliances or technology licensing (Lichtenthaler, 2007). R&D activities are value shop rather than value chain configurations, and they usually include interrelated tasks (Stabell and Fjeldstad, 1998). Accordingly, the knowledge processes are not entirely sequential. Instead, multiple feedback loops require integrated processes (Crossan et al., 1999; Venkatraman, 1994).

Our framework builds on insights from the classic evolutionary model of variation–selection–retention (Campbell, 1960). We extend these principles to our capability-based view of open innovation processes, which involve multiple interactions with a firm's environment (Chesbrough, 2003). Following Zollo and Winter (2002), knowledge exploration is directed at variation, i.e. internally or externally generating new intuitions, and selection, i.e. choosing the most appropriate ideas through evaluation (March, 1991). By contrast, knowledge exploitation encompasses the replication of new approaches in diverse contexts and their internal or external application in different settings (Zollo and Winter, 2002). This application mechanism is a relatively new addition to the standard evolutionary model. Its rationale lies in the observation that organizations differ from biological entities in that variations that survive internal selection are used in multiple applications (Zollo and Winter, 2002). Finally, internal or external knowledge retention

	Knowledge exploration	Knowledge retention	Knowledge exploitation
Internal (Intrafirm)	Inventive capacity	Transformative capacity	Innovative capacity
External (Interfirm)	Absorptive capacity	Connective capacity	Desorptive capacity

Figure 1. Overview of the framework

connects these processes, and it ensures intertemporal knowledge transfer, which can thereby prime the initiation of new processes of knowledge exploration, retention, and exploitation (Garud and Nayyar, 1994; Zollo and Winter, 2002).

To capture internal and external knowledge exploration, retention, and exploitation, we build on prior research and propose six knowledge capacities (Argote et al., 2003; Lane et al., 2006): inventive, absorptive, transformative, connective, innovative, and desorptive capacity (Figure 1). To develop the concept of knowledge management capacity, which refers to a reconfiguring and realigning dynamic capability, we first consider a firm's capacities of managing the distinct knowledge processes. 'A dynamic capability is the capacity of an organization to purposefully create, extend, or modify its resource base' (Helfat et al., 2007, p. 4). Consistent with this definition, firms need to dynamically develop their knowledge capacities to profit from open innovation (Chesbrough, 2006; Teece, 2007).

A firm often has the possibility to organize knowledge processes internally or externally. In knowledge exploration, this issue has been termed 'make-or-buy' decision (Cassiman and Veugelers, 2006). In knowledge retention, firms face the 'integrate-or-relate' issue, which refers to the possibility of incorporating knowledge into the internal knowledge base or relying on interfirm relationships, which represent the external knowledge base. In knowledge exploitation, a firm is confronted with the 'keep-or-sell' problem (Lichtenthaler, 2007). The complementary nature of the internal and external knowledge processes underscores the firm-level coordination requirements, which call for an integrative knowledge management (Cassiman and Veugelers, 2006; March, 1991). A firm needs to successfully reconfigure and realign its knowledge management capabilities to adapt to changing environmental conditions better and sooner than its competitors (Eisenhardt and Martin, 2000).

THE KNOWLEDGE CAPACITIES

Inventive Capacity

Inventive capacity refers to a firm's ability to internally explore knowledge, i.e. to generate new knowledge inside the firm. Starting from the perception of particular opportunities (Shane, 2000), a firm sets up knowledge exploration processes (Smith et al.,

2005). After generating new knowledge, firms have to integrate this new knowledge into their knowledge bases (Garud and Nayyar, 1994; Kogut and Zander, 1992). The new knowledge is embedded into a firm's knowledge base by establishing links to existing knowledge (Helfat et al., 2007; Nonaka, 1994). Following prior research, which highlighted the importance of knowledge generation and inventive activity (Khilji et al., 2006; Smith et al., 2005), we define inventive capacity as a firm's ability to internally explore new knowledge.

Accordingly, inventive capacity comprises the process stages of internally generating new knowledge and integrating it into the firm's base of existing knowledge (Nonaka, 1994; Smith et al., 2005). The knowledge generation process usually requires time because an invention exceeds a mere idea (Burgelman and Rosenbloom, 1989; Khilji et al., 2006). The generation of new knowledge is usually a reaction to a perceived need for that knowledge (Shane, 2000). However, it does not occur in abstraction from a firm's current knowledge base (Kogut and Zander, 1992; Leonard-Barton, 1992). As a consequence, the level of inventive capacity is strongly affected by a firm's level of prior knowledge in a particular field because it facilitates the generation and integration of new knowledge (Khilji et al., 2006). Lucent Technologies, for instance, built up an outstanding inventive capacity based on its internal research activities (Riordan, 2005). In a similar vein, many important electronics technologies were invented in research centres of Xerox in the 1980s (Chesbrough, 2003; Loutfy and Belkhir, 2001).

Absorptive Capacity

While inventive capacity refers to internally exploring new knowledge, absorptive capacity relates to exploring external knowledge. Based on Cohen and Levinthal's (1990) original definition of recognizing, assimilating, and applying external knowledge, Zahra and George (2002) differentiated between potential and realized absorptive capacity. In a similar vein, Lane et al. (2006) distinguished exploratory, transformative, and exploitative learning processes. Following these reconceptualizations, absorptive capacity in the knowledge management capacity framework focuses on knowledge acquisition, i.e. potential absorptive capacity (Zahra and George, 2002) and exploratory learning (Lane et al., 2006). Because of this focus on knowledge exploration processes (Lichtenthaler, 2009), it does not guarantee successful knowledge commercialization, which is part of the knowledge exploitation processes. On this basis, we define absorptive capacity as a firm's ability to explore external knowledge.

Accordingly, absorptive capacity in the knowledge management capacity framework comprises the process stages of acquiring external knowledge and assimilating this knowledge by means of incorporating it into the firm's knowledge base (Lane et al., 2006; Zahra and George, 2002). For absorptive capacity, firms need prior related knowledge to understand the knowledge that is absorbed (Cohen and Levinthal, 1990; Jansen et al., 2005). Cisco, for example, successfully compensated for lower internal research capabilities relative to Lucent by developing absorptive capacity (Carpenter et al., 2003; Dyer et al., 2004). Another example is Procter & Gamble, which has recently started several initiatives to enhance its absorptive capacity (Huston and Sakkab, 2006).

Transformative Capacity

Transformative capacity refers to a firm's capability of internally retaining knowledge over time (Garud and Nayyar, 1994). Knowledge retention needs to be actively managed based on assigning resources to keeping the knowledge 'alive' (Campbell, 1960; Lane et al., 2006). Otherwise, knowledge will be lost if skills and routines are not used anymore or if employees leave the firm (Szulanski, 1996; Walsh and Ungson, 1991). As a result of recognizing a business opportunity, knowledge has to be reactivated and synthesized with additional knowledge (Pandza and Holt, 2007). Moreover, it must again be internalized through experience (Nonaka, 1994). The term 'transformative capacity' indicates that knowledge is transformed if firms maintain knowledge over time and reactivate it subsequently. Building on Garud and Nayyar's (1994) definition, we therefore define transformative capacity as a firm's ability to retain knowledge inside the organization.

Thus, transformative capacity refers to the process stages of maintaining knowledge in a firm's knowledge base and subsequently reactivating this knowledge (Garud and Nayyar, 1994; Walsh and Ungson, 1991). The more prior knowledge a firm has in a given field, the easier it is to maintain and reactivate additional knowledge (Garud and Nayyar, 1994). These benefits from prior knowledge indicate path-dependencies in knowledge retention (McGaughey, 2002; Pandza and Holt, 2007). For instance, Lucent developed a high level of transformative capacity to retain its R&D results (Rivette and Kline, 2000). In a similar vein, IBM has been the firm with most patent applications worldwide for several years, and it systematically maintains this knowledge over time (Chesbrough, 2003; Dittrich et al., 2007).

Connective Capacity

Interorganizational relationships, e.g. alliances, may be considered as a firm's external knowledge retention (Grant and Baden-Fuller, 2004; Gulati, 1999). Similar to internal knowledge retention, external networks have to be maintained and managed over time (Kale and Singh, 2007). As connective capacity refers to a firm's ability to retain knowledge in interfirm relationships, it comprises elements of alliance capability (Kale and Singh, 2007) and relational capability (Lorenzoni and Lipparini, 1999). However, it focuses on externally maintaining knowledge, and this has often been neglected. In contrast to absorptive capacity, external knowledge retention does not assume inward knowledge transfer. Instead, firms ensure privileged access to external knowledge without acquiring it (Grant and Baden-Fuller, 2004). To gain access to external knowledge, firms often need to be open to transfer some of their own knowledge (Chesbrough, 2006). In sociology, connective capacity refers to the ability to establish links to other elements, and these connections facilitate knowledge access (Luhmann, 1995). Following this logic, we define connective capacity as a firm's ability to retain knowledge outside its organizational boundaries.

Accordingly, connective capacity comprises the process stages of maintaining knowledge in interorganizational relationships and subsequently reactivating this knowledge (Garud and Nayyar, 1994; Grant and Baden-Fuller, 2004). Consistent with internal knowledge retention (Pandza and Holt, 2007), a firm's connective capacity increases

with higher levels of prior knowledge. The more knowledge a company has in a particular field, the easier it is to manage interfirm relationships and to profit from external knowledge retention. For instance, Cisco manages a large alliance portfolio based on its connective capacity (Dyer et al., 2004). Cisco often establishes privileged access to the alliance partners' knowledge without immediate transfer of the knowledge, which is externally retained from Cisco's perspective (Bunnell and Brate, 2000). This extended knowledge base provides Cisco with the options value of accessing the knowledge of multiple partners. In a similar vein, many large pharmaceutical companies simultaneously collaborate with multiple biotechnology firms (Rothaermel and Deeds, 2004).

Innovative Capacity

Innovative capacity is associated with matching inventions with the context of their final market (Cohen and Levinthal, 1990; Khilji et al., 2006). A firm may generate many innovations from a small amount of new knowledge. By contrast, a firm may also lack the ability to exploit a large knowledge base that it has generated and maintained (Lane et al., 2006). As knowledge may be developed internally or acquired from external sources, innovative capacity also represents the realized, i.e. exploitative, component of absorptive capacity (Lane et al., 2006; Zahra and George, 2002). Innovative capacity refers to the application of knowledge that has been explored and retained inside or outside the firm because it requires similar exploitation processes (Khilji et al., 2006; Lane et al., 2006). Therefore, we define innovative capacity as a firm's ability to internally exploit knowledge.

Innovative capacity comprises the process stages of transmuting knowledge and converting this knowledge into new products or services (Khilji et al., 2006). In order to generate innovations from internal or external knowledge, a company needs sufficient prior knowledge (Kogut and Zander, 1992; Smith et al., 2005). Prior knowledge determines whether commercialization opportunities are discovered at all and in which areas they are discovered (Shane, 2000). Based on converting knowledge from internal and external sources, Cisco has a high innovative capacity (Chesbrough, 2003; Riordan, 2005). In a similar vein, Procter & Gamble's number of new product introductions has increased substantially in recent years, and its R&D productivity has grown by nearly 60 per cent (Huston and Sakkab, 2006).

Desorptive Capacity

In science, 'desorptive' refers to the process of desorbing, which constitutes the reverse of absorbing (Zytner, 1992). Thus, desorptive capacity describes a firm's capability of external knowledge exploitation, which is complementary to internal knowledge application in a firm's own products (Lichtenthaler, 2007). External knowledge exploitation refers to outward knowledge transfer, which has recently become a broader trend (Fosfuri, 2006). Because of non-rivalry of knowledge (Grant and Baden-Fuller, 2004), desorbing knowledge does not preclude its internal application. After identifying external knowledge exploitation opportunities based on the monetary and strategic motives for

transferring knowledge, a firm has to transfer the knowledge to the recipient (Rivette and Kline, 2000). Thus, we define desorptive capacity as a firm's ability to externally exploit knowledge.

Desorptive capacity comprises the process stages of identifying external knowledge exploitation opportunities and subsequently transferring the knowledge to the recipient. Because of imperfections in the markets for knowledge, opportunity identification is a major challenge, and it requires sufficient prior knowledge (Fosfuri, 2006; Lichtenthaler, 2007). For instance, Lucent recognized major external knowledge exploitation opportunities (Davis and Harrison, 2001; Riordan, 2005). To capture value from its extraordinary technology portfolio, Lucent was one of the pioneering firms in active technology licensing in the 1990s, and it considerably enhanced its desorptive capacity, e.g. by means of a dedicated licensing function (Rivette and Kline, 2000). In subsequent years, Lucent achieved many strategic benefits from out-licensing, and its annual licensing revenues amounted to hundreds of millions of dollars over multiple years (Rivette and Kline, 2000). In a similar vein, IBM has achieved major monetary and strategic benefits, which include significant licensing revenues and the realization of learning effects by means of active outward knowledge transfer (Chesbrough, 2006). Table I summarizes the process components and examples of firms to illustrate the six knowledge capacities.

KNOWLEDGE MANAGEMENT CAPACITY

The Dynamic Capability Perspective

Knowledge management capacity is defined as a firm's ability to dynamically manage its knowledge base over time by reconfiguring and realigning the processes of knowledge exploration, retention, and exploitation inside and outside the organization. Firms need to continuously transform their knowledge capacities, which dynamically develop in an evolutionary path to fit changing environments (Campbell, 1960; Teece et al., 1997). As such, knowledge management capacity determines which knowledge is incorporated into a firm's knowledge base. Besides redirecting specific knowledge capacities, a firm has to reconfigure their interfaces (Helfat and Peteraf, 2003). Knowledge management capacity therefore includes the reconfiguration and realignment of the knowledge capacities. Thus, knowledge management capacity is not a capability that merely connects the knowledge capacities. It includes this connecting function, but it goes beyond that. While the knowledge capacities refer to processes at the knowledge level (Eisenhardt and Martin, 2000), knowledge management capacity refers to transforming the knowledge capacities, thus adopting a perspective above the capacity level. Accordingly, it may be regarded as a 'second-order' dynamic capability, which is directed at 'meta-processes' that make a firm's knowledge management add up to more than the sum of the knowledge processes (Zahra et al., 2006; Zollo and Winter, 2002). In the following, we discuss the reconfiguration and realignment of the knowledge capacities. In addition, we address the role of a firm's strategy and different organizational mechanisms to achieve this reconfiguration and realignment.

Reconfiguration of the knowledge capacities. The knowledge capacities may enable a firm to gain superior innovation performance in one period, but they are most likely insufficient

Table I. Illustration of knowledge capacities

Knowledge capacity	*Capacity components*	*Illustrative examples*
Inventive capacity (internal exploration)	■ Generate ■ Integrate	■ Based on a strong inventive capacity, Lucent developed multiple radically new technologies over several decades (Davis and Harrison, 2001; Riordan, 2005). ■ Many influential electronics technologies were developed in the research centres of Xerox, which had built up a strong inventive capacity (Chesbrough, 2003; Loutfy and Belkhir, 2001).
Absorptive capacity (external exploration)	■ Acquire ■ Assimilate	■ Over many years, Cisco compensated for a lower inventive capacity relative to Lucent by developing absorptive capacity (Carpenter et al., 2003; Dyer et al., 2004). ■ In recent years, Procter & Gamble has started several initiatives to actively strengthen its absorptive capacity (Dodgson et al., 2006; Huston and Sakkab, 2006).
Transformative capacity (internal retention)	■ Maintain ■ Reactivate	■ Lucent developed a strong transformative capacity to maintain the results of its diverse R&D activities over time (Davis and Harrison, 2001; Rivette and Kline, 2000). ■ For several years, IBM was the firm worldwide with most patent applications, and it maintains this knowledge based on a strong transformative capacity (Chesbrough, 2003; Dittrich et al., 2007).
Connective capacity (external retention)	■ Maintain ■ Reactivate	■ Drawing on a strong connective capacity, Cisco manages a large alliance portfolio, which provides privileged access to the alliance partners' knowledge without immediate inward knowledge transfer (Bunnell and Brate, 2000; Kale and Puranam, 2004). ■ Many large pharmaceutical firms, e.g. Pfizer, build on their connective capacities to simultaneously collaborate with multiple biotechnology firms (Bierly and Chakrabarti, 1996; Rothaermel and Deeds, 2004).
Innovative capacity (internal exploitation)	■ Transmute ■ Commercialize	■ Based on converting knowledge from internal and external sources into new products, Cisco has developed a strong innovative capacity (Chesbrough, 2003; Moore, 2007). ■ By strengthening its innovative capacity, Procter & Gamble has substantially increased its number of new product introductions, and its R&D productivity has recently grown by nearly 60 per cent (Dodgson et al., 2006; Huston and Sakkab, 2006).
Desorptive capacity (external exploitation)	■ Identify ■ Transfer	■ Lucent was one of the pioneering firms in active technology licensing, and it considerably enhanced its desorptive capacity, e.g. by means of establishing a dedicated licensing function (Rivette and Kline, 2000; Riordan, 2005). ■ Based on a strong desorptive capacity, IBM has achieved major monetary and strategic benefits from transferring technology, including significant licensing revenues and learning effects (Chesbrough, 2006; Lichtenthaler, 2007).

in sustaining superior innovation over time. The intertemporal perspective of our framework therefore emphasizes the need for dynamically developing a firm's knowledge capacities based on variation–selection–retention processes (Campbell, 1960; Floyd and Wooldridge, 1999). It is necessary to reach behind a firm's ability to manage knowledge exploration, retention, and exploitation to understand that the knowledge capacities themselves must be adaptable (Helfat et al., 2007). To address changing environments, the knowledge capacities have to be reconfigured by active management because fit is not only a state but also a process (Floyd and Lane, 2000; Miles and Snow, 1994). The reconfiguration of the knowledge capacities results from the need to transform a firm's knowledge base as markets and technologies change (Eisenhardt and Martin, 2000). In the evolutionary path from its current knowledge base and market position, a firm may identify new knowledge and markets, revealing a gap between the opportunities and its current position.

To bridge this gap, a firm has to transform its knowledge capacities (Marsh and Stock, 2006). Lucent, for instance, traditionally focused on internally generating new knowledge, but it had to enhance its absorptive capacity to successfully acquire external knowledge (Riordan, 2005). A similar development could recently be observed at Procter & Gamble (Dodgson et al., 2006). These reconfigurations occur in constantly changing adaptation processes that represent attributes of a capability lifecycle, which involves a high degree of causal ambiguity (Dierickx and Cool, 1989; Helfat et al., 2007). The knowledge management capacity framework may therefore advance a firm's strategic planning in the dimensions of integrated and dynamic strategizing (Volberda, 1996). Over time, the reconfiguration of the knowledge capacities is most likely more important than a pure focus on optimizing the different knowledge processes to gain superior performance in one period (Brown and Eisenhardt, 1997).

Realignment of the knowledge capacities. The knowledge capacities need to be realigned over time in order to ensure a sufficient coordination of their interfaces (Grant, 1996). The development of high levels of the knowledge capacities may involve tensions, e.g. regarding knowledge exploration or exploitation (Tushman and O'Reilly, 1996). Moreover, the knowledge capacities need to be combined and integrated to generate synergistic outcomes (Raisch and Birkinshaw, 2008). In open innovation processes, there is a high failure rate in the critical interfaces between the knowledge capacities (Griffin and Hauser, 1992). Thus, firms have to thoroughly realign their knowledge capacities to minimize internal conflict and to maximize complementarities (Cassiman and Veugelers, 2006; Chesbrough, 2006). The causal ambiguity of aligning a firm's knowledge capacities underscores its critical importance in open innovation processes (Dierickx and Cool, 1989).

The realignment of the knowledge capacities helps firms to integrate their internal and external knowledge processes (Hagedoorn and Duysters, 2002; Rothaermel and Deeds, 2004). In one particular project, internal and external processes may represent substitutes. For instance, a firm may decide on the 'make-or-buy' of one particular technology. At the organizational level, however, the internal and external organization of knowledge management processes are often complementary (Cassiman and Veugelers, 2006; Grant and Baden-Fuller, 2004). Accordingly, firms usually do not make 'either–or'

decisions (Cassiman and Veugelers, 2006; Lichtenthaler, 2007). Instead, they simultaneously 'make-and-buy' in knowledge exploration, 'integrate-and-relate' in knowledge retention, and 'keep-and-sell' in knowledge exploitation. For instance, Cisco developed strong inventive capacity to internally arrive at technological breakthroughs and to develop prior knowledge for absorptive capacity, which is complementary to inventive capacity in knowledge exploration (Gawer and Cusumano, 2002). As a consequence, Cisco's technology strength is now higher than the technology strength of the new firm Alcatel-Lucent that resulted from the merger (PatentBoard, 2007). The complementary character of the internal and external knowledge processes increases the need for realignment. Firms may partly compensate for lower levels of an internal knowledge process by relying on the complementary external knowledge process and vice versa (Cohen and Levinthal, 1990; Zahra and George, 2002). However, firms cannot fully replace their internal knowledge processes because of asset mass efficiencies (Cassiman and Veugelers, 2006; Dierickx and Cool, 1989).

Besides coordinating internal and external knowledge, the realignment of the knowledge capacities facilitates the integration of knowledge exploration, retention, and exploitation, which may provide major benefits (Chesbrough, 2006; March, 1991). For instance, firms with high inventive capacities, e.g. Lucent, often develop a broad technology portfolio, and innovative capacity is critical for knowledge exploitation (Gibson and Birkinshaw, 2004). Lucent often had problems in matching its knowledge with final applications, timing the entry of new products, and addressing different market segments (Carpenter et al., 2003; Chesbrough, 2003). The limited balance between Lucent's inventive and innovative capacities resulted in insufficient market orientation. Based on its high level of inventive capacity, however, Lucent was one of the pioneering firms in strengthening its desorptive capacity (Rivette and Kline, 2000). On this basis, its absorptive capacity now interacts with its desorptive capacity in bi-directional knowledge transfers, e.g. cross-licensing agreements (Rivette and Kline, 2000). Table II summarizes the process components and examples of firms to illustrate knowledge management capacity.

Strategic emphasis. Open innovation processes underscore the role of a firm's environmental context (Chesbrough, 2006). Although a firm may partly influence its environment over time, evolutionary processes and capabilities are context-dependent (Baum and McKelvey, 1999; Teece, 2007). For instance, industrial firms often face new technological developments from competitors (Smith et al., 2005). On this basis, our framework underscores the active alignment of a firm's knowledge base and strategy, thereby partly shaping the firm's industry and competition (Teece, 2007). Based on articulating its strategic intent, a firm has to identify the knowledge required to execute its intended strategy (Grant, 1996). A comparison of that knowledge with the firm's current knowledge reveals a strategic gap (Zack, 1999), which provides the foundation for reconfiguring and realigning a firm's knowledge capacities.

A firm's strategy has a major impact on the relative level of the knowledge capacities. The more important the knowledge processes are for gaining and sustaining economic innovation success based on unique knowledge positions, the higher is the necessary level of the knowledge capacities. For example, Lucent's strategy of internally developing

Table II. Illustration of knowledge management capacity

Dynamic capability	*Capacity components*	*Illustrative examples*
Knowledge management capacity	■ Reconfigure ■ Realign	■ Traditionally, Lucent focused on internally generating new knowledge, but it had to draw on its knowledge management capacity to enhance its absorptive capacity in order to successfully acquire external knowledge (Riordan, 2005). Based on its high inventive capacity, Lucent was one of the pioneering firms in strengthening desorptive capacity to benefit from active technology licensing (Davis and Harrison, 2001). On this basis, its absorptive capacity now interacts with its desorptive capacity in bi-directional knowledge transfers, e.g. cross-licensing agreements (Rivette and Kline, 2000). However, Lucent's difficulties in innovative capacity and knowledge management capacity resulted in limited economic innovation success, and they have led to the merger with Alcatel (Rowe, 2006). ■ Cisco acknowledged the need for high inventive capacity to internally arrive at technological breakthroughs and to develop prior knowledge for absorptive capacity (Bunnell and Brate, 2000; Gawer and Cusumano, 2002). Thus, it built on its knowledge management capacity to reconfigure its inventive capacity over years (Ferrary, 2003; Chatman et al., 2005). As a consequence, Cisco's technology strength is now higher than the technology strength of the new company Alcatel-Lucent (PatentBoard, 2007). ■ Procter & Gamble established a systematic process for integrating external knowledge in the innovation process with the goal of acquiring 50 per cent of all innovations from external sources (Dodgson et al., 2006). To support this process of reconfiguring absorptive capacity, Procter & Gamble has set up incentive systems to reduce 'not-invented-here' attitudes. Thus, it draws on its knowledge management capacity to enhance the interface between inventive and absorptive capacity (Huston and Sakkab, 2006). ■ Texas Instruments has promoted the strategic integration of technology licensing in the innovation process, thereby strengthening the alignment of desorptive and innovative capacity (Lichtenthaler, 2007). Building on its knowledge management capacity, Texas Instruments regularly sets up projects to enhance its desorptive capacity and to coordinate outward knowledge transfer with its innovative capacity (Chesbrough, 2003).

radical technological innovations required a strong inventive capacity (Riordan, 2005). By contrast, Cisco's strategic emphasis on acquiring external knowledge in alliances required a relatively lower level of inventive capacity, but a higher level of absorptive capacity (Kale and Puranam, 2004; Moore, 2007). Because of time compression diseconomies, it is difficult to rapidly develop knowledge capacities without sufficient prior knowledge (Dierickx and Cool, 1989). However, firms may actively enhance their knowl-

edge capacities over time in order to close strategic knowledge gaps (Helfat et al., 2007). The example of Lucent further shows that a relative lack of one knowledge capacity, e.g. innovative capacity, may lead to the under-utilization of opportunities that derive from other capacities, e.g. inventive capacity (Riordan, 2005). By contrast, a firm may also partly compensate for a lower level of one capacity with higher levels of other capacities (Khilji et al., 2006).

Based on their strategic intent, firms need to put particular emphasis on specific combinations of internal and external knowledge exploration, retention, and exploitation processes (Zack, 1999). In addition, the benefits from a strong knowledge management capacity will materialize to a higher degree in dynamic environments. For instance, Lucent had difficulties in adapting to the growing technological and market turbulence. Based on increasing competition and limited demand for existing products, these trends required a major reconfiguration of the knowledge capacities (Carpenter et al., 2003). In addition, the increasing development of inventive capacity at major competitors, e.g. Cisco, reduced Lucent's possibilities to achieve high economic innovation performance based on its inventive capacity (Chatman et al., 2005; PatentBoard, 2007). Finally, Lucent's difficulties in innovative capacity and knowledge management capacity resulted in limited innovation success, and they have led to the merger with Alcatel, which involved the acquisition of Lucent billed as a merger of equals (Rowe, 2006).

Thus, decisions on developing the knowledge capacities and knowledge management capacity need to be aligned with a firm's strategy (Chesbrough, 2006; Teece, 2007). For instance, Zack (1999) distinguishes conservative knowledge strategies, which focus on internal knowledge exploitation, from aggressive knowledge strategies, which involve internal and external knowledge exploration and exploitation. Firms that pursue a conservative knowledge strategy primarily need to emphasize innovative capacity, whereas major investments in the other knowledge capacities will often lead to excessive capacity levels. By contrast, firms that pursue an aggressive knowledge strategy need relatively high levels of most knowledge capacities to successfully implement their strategy. A particular strategic intent needs to be complemented by sufficient capacity levels to ensure the successful realization of a firm's opportunities (Helfat et al., 2007). In a similar vein, Bierly and Chakrabarti's (1996) systematization of knowledge strategies, which include explorers, exploiters, loners, and innovators, illustrates the important role of strategy. While insufficient levels of a knowledge capacity may limit a firm's economic innovation success, investments independent of a firm's strategy do not necessarily enhance innovation performance. An excessive level of knowledge capacities relative to a firm's strategy leads to knowledge slack, which may have positive and negative consequences (Voss et al., 2008).

Organizational mechanisms. The literature on dynamic capabilities, knowledge management, and learning points to several means of reconfiguring and realigning the knowledge capacities based on a firm's strategy (Helfat et al., 2007; Kogut and Zander, 1992; Zahra et al., 2006). In particular, prior research has examined the coordination of internal and external knowledge processes and the alignment of knowledge exploration, retention, and exploitation (Cassiman and Veugelers, 2006; Gibson and Birkinshaw,

2004; Jansen et al., 2005). On this basis, a recent review article specifically emphasizes three types of organizational mechanisms (Raisch and Birkinshaw, 2008). Structural mechanisms allow several knowledge capacities to be developed in different organizational units. By contrast, contextual mechanisms allow different knowledge capacities to be pursued within the same unit. Finally, leadership mechanisms abstract from particular units, and they make the top management team responsible for reconciling possible tensions between knowledge capacities.

Structural mechanisms refer to dedicated organizational structures that facilitate reconfiguration and realignment (Kale and Singh, 2007). One approach is spatial separation, which suggests that different knowledge processes are carried out in distinct organizational units, and dedicated structures ensure their reconfiguration and realignment (Tushman and O'Reilly, 1996). Thus, firms may rely on multiple tightly coupled subunits that are themselves loosely coupled with one another (Helfat et al., 2007). For instance, several firms have a dedicated alliance function, which coordinates their alliances and supervises the integration of external knowledge in the internal knowledge bases (Chesbrough, 2006; Kale and Singh, 2007). Moreover, many firms have a corporate development department, which focuses on the dynamic reconfiguration of particular knowledge capacities (Helfat et al., 2007). As an alternative to spatial separation, firms may develop parallel structures. Here, a formal primary structure for ordinary processes is complemented by secondary structures, e.g. project teams or networks, which address specific processes and manage critical interfaces and changes (Gibson and Birkinshaw, 2004). Texas Instruments is an example of a firm that regularly sets up projects to strengthen its desorptive capacity and to coordinate outward knowledge transfer with its innovative capacity (Chesbrough, 2003).

Besides structural mechanisms, successful reconfiguration and realignment may be achieved by means of contextual mechanisms, which refer to the systems, processes, and beliefs that shape behaviours (Gibson and Birkinshaw, 2004). Firms may design this context to encourage all subunits and individuals to facilitate coordination and renewal by actively managing changes and interfaces with other units. Examples are job-enrichment schemes and the creation of a shared vision to allow for knowledge integration and development (Matusik and Heeley, 2005). Procter & Gamble, for instance, established a systematic process for integrating external knowledge in the innovation process with the goal of acquiring 50 per cent of all innovations from external sources (Huston and Sakkab, 2006). To support this process, Procter & Gamble has set up incentive systems to reduce 'not-invented-here' attitudes in order to enhance the interface between inventive and absorptive capacity (Huston and Sakkab, 2006).

Finally, leadership mechanisms are a supporting factor when implementing structural and contextual mechanisms (Tushman and O'Reilly, 1996). The role of senior executives in developing dynamic capabilities has been frequently highlighted (Helfat et al., 2007; Zahra et al., 2006). For example, the top management team usually decides on concurrent engineering to integrate internal and external knowledge and to realign inventive and innovative capacity (Gawer and Cusumano, 2002). In addition, leadership mechanisms may directly contribute to reconfiguring the knowledge capacities, e.g. by means of dynamic resource shifts of top management (Floyd and Lane, 2000; Gibson and Birkinshaw, 2004). Thus, senior executives may balance the development of the knowl-

edge capacities and reduce conflict at interfaces (Helfat et al., 2007). For instance, individual top managers in several firms, e.g. Texas Instruments, have promoted the strategic integration of technology licensing in the innovation process, thereby strengthening the link between desorptive and innovative capacity (Lichtenthaler, 2007).

Individual and Organizational Knowledge

Consistent with the original work on absorptive capacity (Cohen and Levinthal, 1990), our framework concentrates on the organizational level. However, a firm's knowledge management capacity strongly depends on the knowledge of its individual members (Grant, 1996; Matusik and Heeley, 2005). The cumulative development of the knowledge capacities and knowledge management capacity builds on prior investments in individual knowledge (Cohen and Levinthal, 1990). While the knowledge capacities draw our attention to the diverse capabilities in knowledge processes, knowledge management capacity emphasizes their combination. Beyond the importance of individuals in knowledge creation (Smith et al., 2005), knowledge management capacity contains some elements that are distinctly organizational (Nonaka, 1994). In support of this view, recent work on capability development has shown that relevant knowledge lies across different levels of analysis (Helfat et al., 2007; Teece, 2007). For instance, innovative capacity is determined by individual, organizational, and interorganizational knowledge (Rothaermel and Hess, 2007). New insights and ideas usually begin with the individual but, if successful, they are eventually embedded in the organization (Crossan et al., 1999). Thus, capability development can be conceptualized as a dynamic learning process across different levels (Zahra et al., 2006).

By considering open innovation processes, our framework puts emphasis on the interorganizational level in addition to the individual, group, and organizational level that Crossan et al. (1999) addressed in their 4I learning processes of intuiting, interpreting, integrating, and institutionalizing. Through these learning processes, knowledge from the individual, group, organizational, and interorganizational levels is institutionalized in the firm. In turn, this institutionalization creates a context through which subsequent activities are interpreted, and a path-dependent capability development cycle emerges (Helfat and Peteraf, 2003). As the relevant knowledge is distributed across different organizational levels and units, collective knowledge processes and social integration mechanisms strongly contribute to capability development because they facilitate knowledge sharing and integration (Matusik and Heeley, 2005; Nahapiet and Ghoshal, 1998). For instance, Lucent's evolution from focusing on internal R&D to actively acquiring external knowledge in response to Cisco's innovation strategy required the development of absorptive capacity (Ferrary, 2003; Riordan, 2005). This evolution usually involves changes at different levels, e.g. overcoming 'not-invented-here' attitudes of individual employees (Cohen and Levinthal, 1990) and establishing a dedicated alliance function at the organizational level (Kale and Singh, 2007).

The distinction of the knowledge capacities and knowledge management capacity underscores the trade-off between efficiency and flexibility in capability development. A repeated use of the knowledge capacities with limited reconfiguration renders them more difficult to future change (Zahra et al., 2006). By contrast, a continuous renewal of the

knowledge capacities based on a high level of knowledge management capacity likely increases the costs of using the knowledge capacities (Helfat et al., 2007). While the exercise of knowledge management capacity keeps the knowledge capacities flexible, it likely involves costs at the knowledge capacity level. However, it decreases the costs of future uses of knowledge management capacity (Zahra et al., 2006). Thus, an increase in the knowledge capacities and in knowledge management capacity does not automatically enhance a firm's economic innovation performance. It is therefore critical to examine the fitness of a firm's capabilities.

Technical and Evolutionary Fitness

The definition of capabilities shows that capabilities only refer to a firm's capacities in a particular field (Teece, 2007). Thus, any tautology with regard to superior performance is excluded (Helfat et al., 2007; Zahra et al., 2006). Moreover, the function that a capability performs is repeatable, and capabilities contain some patterned element (Winter, 2003). Firms can rely on their knowledge management capacities on a repeated rather than idiosyncratic basis, and economic innovation performance does not necessarily improve (Helfat et al., 2007; Zollo and Winter, 2002). In addition, the development of the knowledge capacities and knowledge management capacity may involve substantial costs, which may limit economic innovation performance. Finally, a capability increase that derives from additional prior knowledge may even negatively affect performance independent of its costs in specific settings, e.g. in situations where codified knowledge plays a central role (Haas and Hansen, 2005).

We therefore draw on the notion of technical fitness, which describes how effectively a capability performs its intended function when divided by its cost (Helfat et al., 2007; Teece, 2007). Thus, it refers to the quality of a capability in relation to the cost of its creation and utilization. Accordingly, technical fitness reflects a firm's productivity in developing and executing a capability. Quality and cost do not have a one-to-one relationship, which would suggest that high quality automatically involves high costs (Helfat et al., 2007). Although superior quality levels often lead to higher costs, this relation does not always hold. Cisco, for example, reduced its transaction costs by developing absorptive capacity (Bunnell and Brate, 2000). As a consequence, the cost of external knowledge acquisition decreased (Chesbrough, 2003). Thus, higher capability levels do not necessarily involve higher costs.

In a similar vein, an increase in the knowledge capacities does not automatically lead to superior innovation performance. It is therefore critical to examine technical fitness instead of exclusively focusing on either quality or cost (Helfat et al., 2007). As technical fitness captures both aspects, it most likely has a positive relationship with economic innovation performance. This relationship is not tautological because the knowledge capacities affect a firm's innovation success through the performance of the specific knowledge processes (Burgelman and Rosenbloom, 1989; Cohen and Levinthal, 1990). Depending on the strategic importance of these processes, a firm's economic innovation performance will increase. For instance, learning processes based on absorptive capacity contributed to Cisco's innovation success because they affected its knowledge acquisition performance (Dyer et al., 2004; van den Bosch et al., 1999). By contrast, knowledge

management capacity determines a firm's innovation success primarily through the outcome of the knowledge capacities (Eisenhardt and Martin, 2000; Zahra et al., 2006).

However, technical fitness of the knowledge capacities and knowledge management capacity is necessary but not sufficient to achieve economic innovation performance. As capabilities are context-dependent, the knowledge capacities need to match a firm's environment (Burgelman and Rosenbloom, 1989; Helfat et al., 2007). Beyond technical fitness, firms therefore need evolutionary fitness in open innovation processes. 'Evolutionary fitness refers to how well a dynamic capability enables an organization to make a living by creating, extending, or modifying its resource base' (Helfat et al., 2007, p. 7). The requirement of evolutionary fitness reflects the trade-off between developing and exercising the knowledge capacities or knowledge management capacity. The development of capabilities may increase their technical fitness, but it may not enhance their evolutionary fitness. Thus, the knowledge capacities and knowledge management capacity need not perform equally well on both fitness dimensions.

For instance, a knowledge capacity may have a high evolutionary fitness despite limited technical fitness if the firm operates in a favourable environment (Teece, 2007). Moreover, firms have opportunities to use technically fit capabilities to shape their environment in order to promote the evolutionary fitness of these capabilities (Helfat et al., 2007). To enhance a firm's economic innovation performance, a capability's technical fitness must be heterogeneous across competitors (Barney, 1991). Moreover, these capabilities must be rare in relation to the demand for their services (Helfat et al., 2007). In addition, substitutes must be limited (Eisenhardt and Martin, 2000). Otherwise, competition would erode the value of the capabilities (Helfat et al., 2007). Cisco, for example, relied on the high technical fitness of its absorptive capacity to constantly innovate (Bunnell and Brate, 2000). As a consequence, its evolutionary fitness increased. However, firms do not have unlimited opportunities to increase their evolutionary fitness because all firms operate within resource and environmental constraints (Helfat et al., 2007).

DISCUSSION

Knowledge management capacity refers to a firm's ability to manage its knowledge base over time. By drawing on capability-based arguments (Helfat et al., 2007), the framework considers the dynamic interaction of internal and external knowledge in open innovation processes. As such, it represents an integrative approach to knowledge management, for which multiple authors have called (Argote et al., 2003; Grant, 1996). This integrative view is complemented by six knowledge capacities. While the knowledge capacities underscore the diverse challenges in managing internal and external knowledge, knowledge management capacity emphasizes the need for coordinating the processes and for renewing a firm's knowledge base, thereby transforming the foundations of superior innovation performance.

Theoretical Implications and Future Research Directions

This article has implications for research into knowledge management, open innovation, dynamic capabilities, ambidexterity, firm boundaries, and growth strategies. Regarding

knowledge management, the framework integrates prior knowledge management research as it relates to innovation processes, absorptive capacity, and dynamic capabilities. Thus, it extends the process-based view of absorptive capacity (Lane et al., 2006), which focuses on the external exploration, internal retention, and internal exploitation of knowledge (Lichtenthaler, 2009). Beyond absorptive capacity, our framework emphasizes that all three processes, i.e. knowledge exploration, retention, and exploitation, may be organized inside and outside a firm's boundaries. As such, this article provides a basis for empirical studies, whose relatively limited number has been highlighted as a deficit of knowledge management research (Argote et al., 2003; Bogner and Bansal, 2007). In particular, our emphasis on reconfiguring and realigning the knowledge capacities extends prior knowledge management research, which often has relatively neglected dynamic views (Marsh and Stock, 2006). Specifically, the framework's focus on knowledge processes helps to complement static analyses of knowledge stocks by examining the knowledge flows in a firm's organizational processes, e.g. product development (Kyriakopoulos and de Ruyter, 2004).

With regard to open innovation, the framework integrates insights from several lines of research to advance towards a theory of open innovation. As such, it helps to overcome the theoretical deficits of prior open innovation research, which limited our understanding of open innovation processes (Lichtenthaler, 2008). The illustrative examples of Lucent, Cisco, and other firms have shown that knowledge management capacity deepens our understanding of interfirm heterogeneity in profiting from open innovation (Chesbrough, 2006). Specifically, the framework may be used to identify potential sources of innovation, which may be localized at the knowledge capacity level and at the knowledge management capacity level. By considering the interactions of internal and external knowledge, our framework contributes to explaining various recent developments. For instance, the interactions help to understand the trend towards developing desorptive capacity because many firms attempt to capture additional value from their strong inventive capacities by licensing technology (Lichtenthaler, 2007).

Concerning dynamic capabilities, our arguments draw attention to balancing strategy formulation with sufficient flexibility in changing environments (Burgelman and Rosenbloom, 1989; Volberda, 1996). Here, this article extends prior dynamic capabilities research by pointing to an important trade-off. While the path-dependent development of the knowledge capacities enhances their technical fitness, they become more resistant to reconfiguration (Zahra et al., 2006). Firms therefore need to balance the use of the knowledge capacities and knowledge management capacity based on the degree of environmental turbulence. As the knowledge capacities and knowledge management capacity are not necessarily associated with innovation success (Helfat et al., 2007; Teece, 2007), the framework highlights the need for examining a firm's strategy in capability development. In addition, knowledge management capacity may have to be reconfigured based on a firm's strategy. This process of variation-selection-retention may over time lead to an 'infinite spiral' of developing capabilities to renew capabilities (Zahra et al., 2006).

Regarding ambidexterity research (Ambos et al., 2008; Tushman and O'Reilly, 1996), the framework suggests that firms need to balance the development of the knowledge capacities. In particular, firms not only need to achieve internal balance but also have to

design their knowledge processes to achieve evolutionary fitness at their organizational boundaries (Zajac and Olsen, 1993). For instance, Lucent traditionally excelled at inventive capacity, but it had difficulties in internally exploiting its knowledge (Carpenter et al., 2003). However, Lucent enhanced its balance between exploration and exploitation by strengthening its technology licensing activity through actively developing desorptive capacity (Chesbrough, 2003). Thus, this article points to new types of ambidexterity by combining internal and external knowledge processes because prior ambidexterity research has usually focused on exploration and exploitation inside the firm (Raisch and Birkinshaw, 2008). Cisco, for example, combined its strong innovative capacity with a high level of absorptive capacity. These ways of achieving ambidexterity by aligning internal and external knowledge management processes represent a particularly fruitful avenue for further research.

With regard to the literature on organizational boundaries, the framework calls into question traditional assumptions in boundaries research. In particular, transaction costs do not exclusively determine firm boundaries (Santos and Eisenhardt, 2005). Instead of relying on transaction cost considerations to either make or buy knowledge in open innovation processes, for instance, firms often simultaneously rely on their inventive and absorptive capacities in exploring knowledge (Cassiman and Veugelers, 2006). As a consequence of integrating individual and organizational knowledge over time, knowledge boundaries may mismatch vertical or horizontal firm boundaries (Grant and Baden-Fuller, 2004). To successfully capitalize on this knowledge, firms need to maximize value besides minimizing costs in boundary decisions (Zajac and Olsen, 1993). Accordingly, our framework puts emphasis on non-efficiency perspectives, which go beyond transaction cost analyses (Santos and Eisenhardt, 2005).

For instance, capability-based reasoning suggests rethinking the relationship between product business and technology licensing. Being active in several product markets is the best way to gain knowledge about these and related markets (Kogut and Zander, 1992). Because of the need for prior knowledge in developing desorptive capacity, there may be synergies in internal and external knowledge exploitation. In contrast to assumptions in the international market entry literature (Mirus, 1980), diversification and licensing appear to be complements rather than substitutes in open innovation processes (Lichtenthaler, 2007; Silverman, 1999). On this basis, our framework has implications for research into knowledge transfer, especially university-based technology transfer. As universities usually lack a product business, their understanding of product markets is limited. The importance of prior knowledge for successful knowledge exploitation therefore provides a new perspective on the difficulties of research institutions in commercializing technology (Wright et al., 2006).

Regarding growth strategies, the framework systematizes the exploitation of existing knowledge inside and outside a firm's boundaries (Argote et al., 2003). Thus, it contributes to understanding a firm's relative emphasis on internal or external growth strategies (Burgelman and Rosenbloom, 1989; Helfat et al., 2007). New knowledge is often a product of a firm's capability of generating new applications from existing knowledge (Kogut and Zander, 1992). Learning tends to be local, and incorporating proximate knowledge does not require changes in a firm's organizational structure (Zahra et al., 2006). Therefore, the development of the knowledge capacities and knowledge manage-

ment capacity is likely based on a firm's prior development path. Thus, our framework contributes to explaining path-dependencies and related diversification in extending a firm's knowledge base over time (Silverman, 1999). Specifically, future studies may rely on the framework's dynamic perspective to complement existing analyses of knowledge-related diversification at one point in time (Tanriverdi and Venkatraman, 2005).

Accordingly, we encourage empirical studies into the organizational antecedents and performance consequences of the knowledge capacities and knowledge management capacity. Prior empirical work into absorptive capacity, strategic alliances, and new product development may provide helpful starting points. For instance, a meta-analysis based on our framework will facilitate the integration of earlier findings. In particular, the interactions of the knowledge capacities may provide new insights. Here, this article could only present illustrative examples, which help to explain observed firm behaviour, e.g. the development of desorptive capacity based on strong inventive capacity (Chesbrough, 2006). Although a lot of work remains to be done, knowledge management capacity seems to be a robust framework for empirical research. For instance, further studies may show that the recipient's absorptive capacity is only one determinant of successful knowledge transfer. Particularly in bi-directional knowledge exchange, the absorptive, desorptive, and connective capacities of both firms need to be considered.

Managerial Implications

This article has direct implications for practicing managers. In particular, the framework helps to broaden practitioners' perceptions of knowledge management beyond internal knowledge retention. As the markets for knowledge expand the strategy space (Rivette and Kline, 2000), they offer the potential for radical strategic change. In this respect, our arguments suggest that over time those firms will successfully innovate that cope with the following critical challenges. First, firms need to develop the knowledge capacities to address their current knowledge processes. Second, companies have to build up knowledge management capacity to reconfigure and realign the knowledge capacities. The development of a knowledge capacity requires time and effective knowledge integration across intrafirm boundaries (Crossan et al., 1999). Usually, this evolution has to include changes in organizational structure and culture, e.g. overcoming 'not-invented-here' attitudes (Cohen and Levinthal, 1990). A central challenge that firms face is the creation of a systematic openness to reconfiguring the knowledge capacities in order to shape and adapt to their environment (Zahra et al., 2006). For instance, if new competitors with distinct strategies enter a market, firms may have to reconfigure their knowledge capacities to ensure high economic innovation performance (Teece, 2007).

Conclusion

The knowledge management capacity framework provides an integrative perspective on dynamically managing a firm's knowledge base in open innovation processes. The six knowledge capacities draw our attention to the characteristics and challenges of the different knowledge management processes, whereas knowledge management capacity emphasizes the need for dynamically reconfiguring and realigning these knowledge

capacities. The concept may therefore be regarded as a framework for open innovation, as a complement to absorptive capacity, and as a move towards understanding dynamic capabilities for managing knowledge. The framework necessarily is dynamic because all firms seek superior performance, but they cannot all be superior at the same time. In particular, it shows how to develop, combine, and redirect the knowledge capacities based on a firm's strategy in light of potential interface problems (Griffin and Hauser, 1992). The examples of Lucent, Cisco, and other firms have illustrated that interaction analyses are an important benefit of the framework because multiple knowledge capacities are involved in most organizational processes, e.g. new product development (Kogut and Zander, 1992).

A thorough analysis of the knowledge capacities and knowledge management capacity reveals which capacities are well developed, e.g. Cisco's absorptive capacity (Chesbrough, 2003). In addition, it shows where a firm has deficits, e.g. Lucent's limited innovative capacity (Riordan, 2005). By systematically addressing the knowledge capacities, their interfaces, and their interactions, the framework helps to identify knowledge management bottlenecks, which negatively affect a firm's economic innovation performance (Lane and Lubatkin, 1998). Thus, the capability-based framework may contribute to operationalizing knowledge management and open innovation. While further conceptual and empirical work is required to tighten the framework, the integration of the knowledge capacities and knowledge management capacity will facilitate the analysis of interfirm heterogeneity in knowledge and alliance strategies, organizational boundaries, and innovation performance.

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