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Modes of E-business Innovation and Structural Disruptions in Firm Knowledge

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This paper explores the linkages between knowledge integration strategy and the modes of innovation in architecturally destructive e-business settings. Knowledge management (KM) is linked to the concepts of component and architectural knowledge in complex, global e-business networks. Understanding the structural impact of incremental, radical, architectural, and modular innovations at the business model- and systems-level on knowledge configurations can better guide KM strategy formulation. By delineating these linkages, this paper concludes with implications for managers of globalized teams and highlights open areas for future research. Copyright © 2002 John Wiley & Sons, Ltd.

INTRODUCTION

As e-business transforms industries, markets, and firms, both existing and born-on-the-Web businesses are rushing to embrace it. In this eagerness, the so-called pure-play e-businesses come with little firm history, antecedent, and path dependency. In contrast, traditional firms moving to the Web frequently face the question of whether and how what they already know can be of business value in this new environment. Furthermore, as systems development processes become increasingly globalized, knowledge management across national borders that many firms span becomes key to performance. Academic research on this topic is divided between the epistemological camp that believes existing information systems theory must be abandoned in favor of new theories specific to this global environment, and the other that puts more faith in the timelessness and robustness of our theoretical heritage.

This paper revisits extant research in light of this new business phenomenon to examine knowledge management in global, cross-border projects.

The role of knowledge management in radically and incrementally innovative, cross-border, global e-business project teams is examined. The need for drawing boundaries between business model- and systems-level innovation is highlighted. The conceptual centrality of *integration* to knowledge management and the differences in approach under various modes of innovation are also elaborated. Finally, and a rich agenda for linking knowledge management for competitive agility in e-business is outlined.

RECONFIGURATION OF VALUE NETWORKS IN E-BUSINESS

E-business is described as Internet-facilitated integration of business processes, applications, and information systems (Tiwana and McLean, 2001). Although e-business is largely a business phenomenon, it is enabled by the information systems that facilitate it. Translation of business needs into online systems capabilities is largely a function of a firm's execution capability. How well or how poorly such translation occurs largely determines the level of alignment between e-business models and e-business information systems.

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Cross-border value networks

Contrasting traditional firm structures, their hierarchies, and value chains with those of e-businesses reveals a key difference, as illustrated in Figure 1. In traditional firms, customers often interacted directly with only one given division of the firm. Occasionally, this interaction was later-order such as through dealers, distributors, and retailers rather than the manufacturer. Again, in product or service delivery, a single department such as Marketing or Sales was primarily involved. If we consider three internal business units of a firm *A*, *B*, and *C*, and their suppliers *D* and *E* as illustrated, customers typically interacted with business unit *C* only. Coordinating the activities of *A*, *B*, *D*, and *E* was a function either monitored by *C* or managed by higher-level management.

Likewise, the extent to which knowledge needed to be shared across the value chain was moderated by the caution of overinvesting in it. Furthermore, firm boundaries were clearly drawn, with little confusion over the role of involved external business partners such as suppliers and distributors. In summary, knowledge integration across the entire channel was likely to show positive net benefits only till a marginal threshold was reached.

Next, consider the same set of relationships *ex post* e-business. This point is perhaps better illustrated through an exemplar from which we can abstract to a higher level of generality. Dell Computer Corporation, an Austin, TX-based manufacturer of personal computers uses a variety of suppliers. These suppliers provide Dell open-standards-based components that Dell integrates into computer systems that are configured on demand, and specific to individual customers' needs. Dell also manages a complex supply chain that is coordinated through Internet-facilitated inventory management systems that allow Dell to maintain among the industry's best inventory turnover rates.

For austerity's sake, consider only the delivery front-end process through which Dell delivers these systems to its customers. Customers self-configure a base computer system to their needs, select memory, disk drives, processor speeds, service contracts, and peripherals through the company's Web site. Once an order is placed, the actual machine is assembled from standardized parts and related peripherals are shipped directly from manufacturers' or co-managed facilities. A sophisticated Internet-based system is used to coordinate delivery to ensure that, say a computer monitor, scanner, and the system itself all arrive together at the customer's door as one package, even though they might all have originated in different locations across the country. With the advent of e-business, the traditional boundaries expand to span multiple cultures, organizations, and even nations. As illustrated in Figure 1, although the customer perceives receiving her order directly from Dell's Sales and Delivery unit C, external business units B and E directly interact with the customer to create that *perception*. This exemplar can very well apply to many other business-to-consumer e-business operations. Several internal and external business units therefore coordinate through the Internet and Internet-based information systems to create a virtual
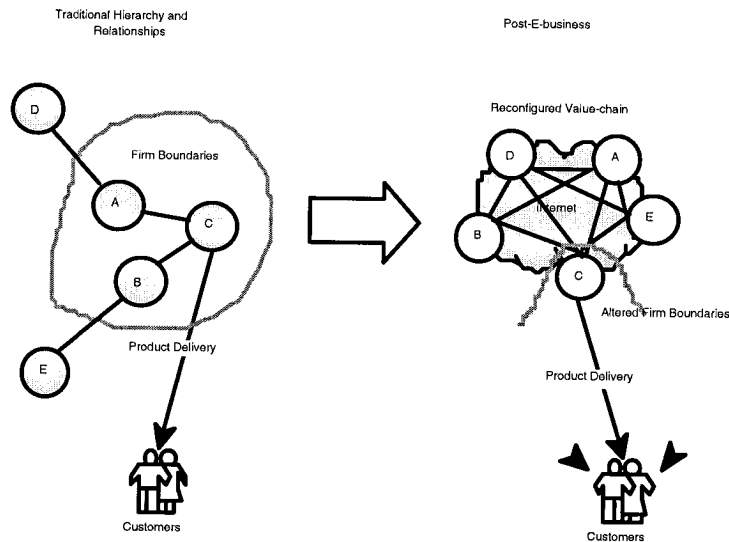

Figure 1   A comparison of traditional and post-e-business value chain and firm boundary configurations

firm (Faucheux, 1997; Townsend *et al.*, 1998; Venkatraman and Henderson, 1998).

Emergent knowledge webs

As value chains are reconfigured, the true boundaries of the 'firm' become harder to discern. Cross-border, global environments are one such oft-encountered manifestation. Given that the coordination complexity in such firms rises, the effects of effective knowledge management across the value chain becomes *more* pronounced. The value chain further begins to resemble a relationship-based web ('value web'). Specifically, the ability of e-businesses to integrate relevant knowledge across the value web constitutes an additional basis for competitive differentiation. Knowledge integration capability then qualifies as a key strategic resource that meets Barney's four touchstones of rare, durable, imperfectly imitable, and non-tradable intangible assets (Barney, 1991, 1999).

Delineating modes of innovation

Innovations can be classified into one of four high-level categories based on how the linkages among specialized areas of knowledge and expertise (architectures), and in those specialized areas themselves (components) change (Henderson and Clark, 1990). Knowledge underlying the distinct, independent components of systems constitutes component knowledge and that of the linkages between them represents architectural knowledge. Therefore, component knowledge refers to knowledge underlying the components of systems (such as e-business information systems and business models). Architectural knowledge relates to knowledge of how these components are brought together to form a coherent whole. Component knowledge has been variously referred to as resources (Amit and Schoemaker, 1993), technical systems of knowing (Teece *et al.*, 1997), and rules-of-thumb (Nelson and Winter, 1982) in past research. Likewise, the concept of architectural knowledge has been labeled variously as architectural competence (Henderson and Cockburn, 1994), integrative capability (Lawrence and Lorsch, 1967), and social implicit knowledge (Spender and Grant, 1996). These four categories are summarized in Table 1.

The boundaries among these modes are rarely black-and-white, therefore classification is largely a matter of degree. The relationships between these innovation modes and structural impact on knowledge assets are discussed later.

Table 1 Innovation modes and impacts on knowledge-based assets

Innovation mode	Component knowledge	Architectural knowledge
Incremental	Stable	Reinforced
Architectural	Stable	Destroyed
Modular	Changed	Stable
Radical	Changed	Changed

COMPLEMENTARITIES AMONG KNOWLEDGE ASSETS

Firms that have excelled in new business environments have rarely relied solely on excelling at one aspect of their business. They often rely more heavily on following strategies that integrate market vision with complementary execution capabilities (Fuchs *et al.*, 2000), each of which is continually honed over time. In e-business, the complexity involved in such integration often exceeds that found in typical pre-e-business firms, primarily increased by the web-like structure of partnerships involving multitudinous business unit participants. In e-business, multiple firms often collaborate through partnerships and strategic alliances. Business units that actually execute these collaborative activities must be able to integrate their unique competencies toward a shared goal. An integrated strategy must take into account the firm's business vision, direction, market focus (niche or head-on competitor to existing firms), and the available tangible and intangible resources. Collectives such as teams, firm networks, and individual firms must understand not just some key elements of strategy and technology. Instead, they must master many (Fuchs *et al.*, 2000), perhaps more so than in the pre-e-business era. Furthermore, they must maximize complementarily with one another and with the business environment (Kogut, 2000; Kogut and Zander, 1993). Finally, the elements of knowledge that are most relevant to the strategic theme of the business must be identified and appropriately emphasized (Tiwana, 2000a). Such response must be integrated into a cohesive strategy rather than replicative imitation of competitors' steps and missteps. Integration of individual areas of expertise relevant to e-business projects is therefore germane to their performance and continued success. In cross-border, global project teams, this implies that knowledge integration must span multitudinous distributed participants.

Levels of analysis for knowledge structures

It is meritorious to tease apart innovation at two distinct but separably intertwined levels: the business model level and the systems level. Although innovation at the business model level might be in a certain mode, systems-level innovation needed to implement that business model might not be in the same mode. The inability of firms to delineate the two might result in gross miscalculations about the type of knowledge management/integration strategy that is needed for a given e-business initiative. A few examples of each perhaps illustrate this subtlety better, as shown in Table 2. These exemplars of radical, modular, incremental, and architectural e-business models illustrate that systems-level innovation in either case is largely architectural in nature.

Although many business models found in e-business are radically innovative, their impact on systems-level innovation that facilitates that model is rarely in the same mode. Therefore, knowledge integration capabilities required for the two dimensions can be surprisingly distal.

STRCUTURAL IMPACT ON KNOWLEDGE ASSETS

Integrating the aforementioned innovation management research theme (Henderson and Clark, 1990; Henderson and Cockburn, 1994; Tushman and Anderson, 1986) and knowledge management theory (Nonaka, 1994; Tiwana, 2000b; Tiwana and McLean, 2001) leads to an initial model that provides a high level framework for analyzing knowledge management requirements in various e-business settings. Note that the model itself is perhaps generalizable to other settings, although the present developmental context is e-business. This model is shown in Figure 2, and its elements are discussed next.

Levels and context

The model must be applied in two related contexts. First, the business model-level must be analyzed beginning by identifying the innovation mode. Second, the innovation mode at the systems level must be identified. Let us randomly pick an example from Table 2, say Napster.com. Napster.com's business model is radically innovative at the business model level in that it fundamentally changes both architectures and components of music distribution. Unlike Internet retail stores, Napster does not own all the infrastructure that it uses. Instead, users' computers host most of the digitized music content, with Napster playing a key mediating role. The company does not buy and sell packaged music in the same manner at traditional brick-and-mortar or online music retailers, operates with very different economics, and relies on building strong lock-ins with its customers (Shapiro and Varian, 1998; Varian, 1980). Therefore, Napster competes using elements different from traditional ways in which the industry has operated (i.e. the components change). Similarly, the ways in which these components come together to form a coherent, whole system is also very different from traditional

Business model	Exemplars	E-business model summary	Systems-level
Radical	Napster.com MP3.com	Peer-to-peer software to distribute and share digitized music using the Web	Architectural
	Application service providers (ASPs)	Software rental delivery through the Web	Architectural
Modular	NewYorkTimes.com	Digital delivery of content through wireless handheld computers	Architectural
	Amazon.com extensions	Extension of the amazon.com brand and infrastructure to retail unrelated products and services	Architectural
Incremental	Eudora	Advertising streaming through existing client software; versioning based on price premiums paid	Architectural
Architectural	WebVan.com	Grocery delivery logistics	Architectural

Table 2 Business model- and systems-level innovation requires different types of knowledge integration capabilities
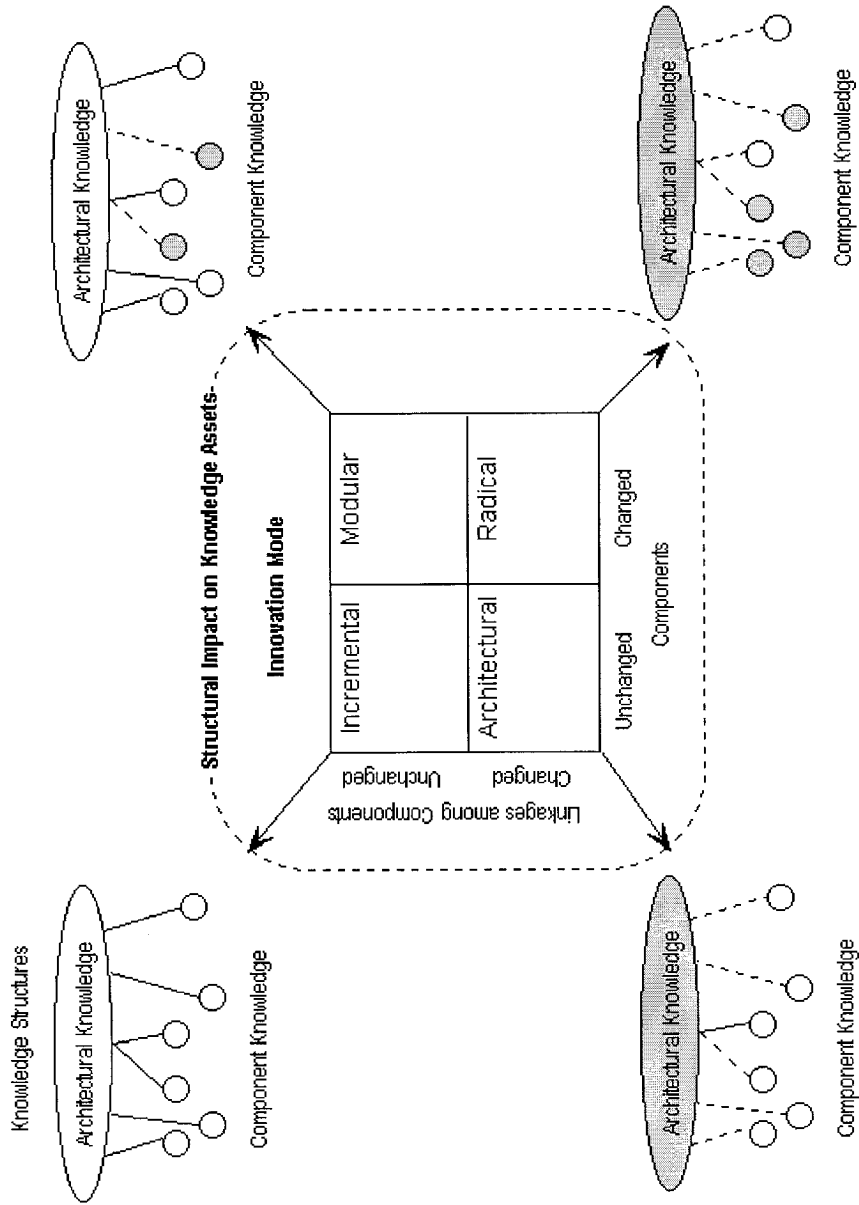
Figure 2 Structural impacts of innovation modes on knowledge-based assets. Aspects that are changed in a given mode of innovation are shaded (aspect) or dotted (linkages)

architectures (i.e., the architecture changes as well). Because both components and their linkages change, the business model is radically innovative. Next, let us examine the systems that allow Napster.com to actually implement this radically innovative business model (Figure 3). A centralized peer-to-peer server based on open Web standards interconnects individual users of the service. Digitized music files are stored on individual members' systems and can be accessed across the entire network (using Napster.com's client software). The Internet provides an open infrastructure that then facilitates direct transactions among individual users. The technology used is therefore a novel recombination of *existing* technologies (Boisot, 1995; Boisot and Griffiths, 1999). This implies that the systems level innovation is largely architectural in nature (existing components are reconfigured using a *new and novel* architecture).

Knowledge structures

Knowledge structures are depicted along the four corners of the model (Figure 2). For each knowledge structure, whether at the business model- or systems-level, the overall manner in which various components are brought together and integrated into a coherent, whole system represents architectural knowledge. Various components that constitute the system are linked to their respective component knowledge. In each mode of innovation, either or both components and architectures

change, as indicated by the shaded elements and the dotted linkages.

Linkages to innovation modes

The innovation mode that applies to an e-business is represented in the 2×2 matrix at the center of the model in Figure 2. Depending on whether components or architectures change, they can be classified as being incremental, architectural, modular, or radical changes. For each type of innovation, the changes that emanate from the cell are represented by the shaded/dotted elements of the altered knowledge structure. It is clear from this illustration that knowledge integration requirements in each mode will be considerably different.

KNOWLEDGE INTEGRATION AS KNOWLEDGE MANAGEMENT?

Knowledge management builds largely on Resource-based Theory of the Firm (Grant, 1991, 1997; Wernerfelt, 1984). In her seminal work that initiated this stream of research, Penrose suggests that it is the services that the firm's resources render that are of value to the firm, not the resources by themselves (Penrose, 1959). If the same logic were applied to knowledge-based assets, it would be fair to suggest that it is the extent to which these assets are actually applied and integrated into a firm's operations that renders them their value. Mere possession of component
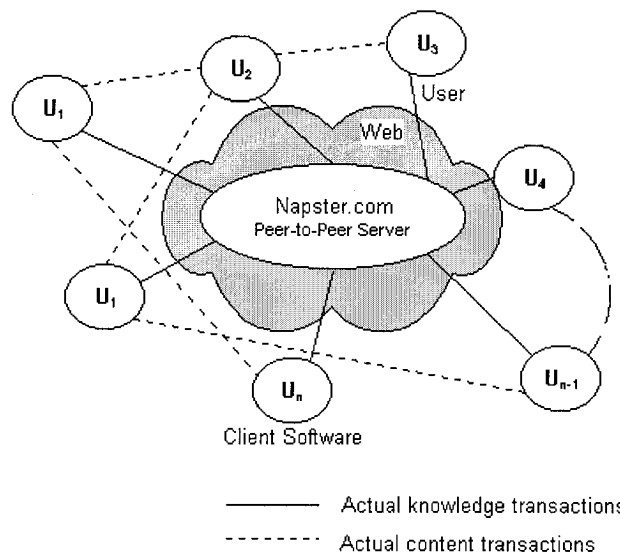

Figure 3   Napster.com relies on an architecturally innovative information system

or architectural knowledge assets would do little to add value in a dynamic business environment. The essence of knowledge management is therefore knowledge integration (Foss, 1996; Grant, 1996a,b).

Challenges in cross-border knowledge integration

The role of multinational, cross-border teams and temporary organizations in knowledge integration has changed considerably over the past decade. As businesses become increasingly transnational and attempt to compete in global markets, cross-border teams offer unprecedented opportunities for creating new, market-specific knowledge through integration. Such team structures facilitate the synthesis of local tacit knowledge with a relatively well-articulated body of global knowledge that is distributed and accessible across individual firms. Such knowledge can help firms compete head-on with domestic and international competitors in each market. Cross-border teams possess three characteristics to which their inherent superiority in knowledge integration can be attributed.

First, they possess a wider *variety* of environmental and market stimuli owing to greater exposure to a sufficiently varied set of customers, competitors, and technologies. This increases their absorptive capacity that in turn shapes their ability to both sense and respond creatively to emerging opportunities at project, firm, network, and market levels.

Second, cross-border teams innovate for specific global markets but are have *access* to innovations in other markets that might have been facilitated within the network of collaborators and within individual participating firms.

Third, cross-border teams have access to a wider variety of resources and *knowledge*. This opens up new opportunities for novel recombinations of existing knowledge — a precursor to new, non-path-dependent architectural knowledge.

Managerial implications

In e-business, like in many other large-scale architecturally destructive business innovations, knowledge integration is the key to competitive performance. E-business is largely an information systems-facilitated transformation wherein the requirements for knowledge management differ at the business model and systems levels. Whether innovation occurs in the form of industry reconfiguration, globalization, or disruption of stable business models, the ability of firms (and teams

within and across firms) to respond is largely moderated by their ability to do so. This capability can be bolstered by carefully selecting members of teams in project-based tasks. The extent to which cross-border, global inter-firm networks develop capabilities to integrate knowledge will largely determine their ability to cope with rapid change, innovation, market instability, and competitive threats.

Focus on identification
A key aspect of knowledge management that adherents have not paid sufficient attention to is that of *identification*. It would serve little purpose to address knowledge integration in e-business project teams as though it were modular, when in fact it is architectural. At the technology level, knowledge structures are largely altered at the architectural level throughout most e-business transitions. This has two implications: (1) specific knowledge components are rarely altered and (2) the linkages between them are destroyed. For existing firms transitioning to e-business, this implies that their existing component knowledge assets are largely reusable in e-business, although their conceptions of how they come together in the new marketspace are not. Such businesses must therefore focus on recreating new market-relevant architectural knowledge from existing component knowledge. It is precisely such identification that managers must focus on in order to improve knowledge integration in global, cross-border projects.

Determine changes in the 'big picture'
Managers of cross-border, global project teams must pay attention to determining how the larger picture of the project has evolved from what has been the norm in their industry. Several studies have documented that architectural innovations are more difficult to detect than other types, especially because the components remain largely unaltered (Galunic and Eisenhardt, 2001; Henderson and Clark, 1990; Henderson and Cockburn, 1994; Tiwana, 2000b; Tiwana and McLean, 2001). This implies that managers who pay attention to the minutiae of project component technologies are less immune to the threat of not recognizing a structural knowledge change at all. Managers must therefore direct their attention to determining how the project has evolved from an architectural perspective in comparison to previously existing solutions.

Stimulate creative abrasion
Recreation of architectural knowledge relies on a certain level of innovative, out-of-the-box thinking.

Such innovative thinking can rarely come from homogenous teams of say, software engineers. Managers must form teams with members drawn from a variety of relevant expertise domains. E-business teams, for example, often draw on software engineers, information and content managers, graphic artists, logistics and operations staff, and psychologists. The copresence of such diverse members can lead to creative conflict that can stimulate creativity in the process of project execution. Whether such teams are better served by co-locations is a question that will have to await further research.

Put the money where the mouth is
Although knowledge integration is a much-needed capability, managers must put in place appropriate incentives to encourage and reward it. Our research on e-business projects shows that individual team members in cross-border teams are frequently evaluated by managers in their home business units. Although this approach might have worked well in incrementally innovative project teams, it fails to provide sufficient intrinsic motivation to share and subsequently integrate the knowledge that individuals perceive as being valuable. Managers must explicitly consider the rewards and incentives aspect of cross-borer teams to create a context that is cognizant of the knowledge hoarding tendency of individual. These reward systems must be powerful enough to overcome the inertia of sharing valuable, individually held knowledge.

Research implications

The aforementioned linkages between knowledge management, knowledge integration, and innovation mode-based structural shifts have three implications for future research on knowledge management.

First, Knowledge *Integration* Theory of the Firm (Demsetz, 1991; Grant, 1996a) deserves closer attention if the field of knowledge management is to progress. This area offers a promising aspect for both theoretical development and empirical testing. This builds further on the argument that the essence of knowledge management is knowledge integration. Research in this area has largely been too broad in scope to emerge with meaningful contributions, or has been too obsessed with the technological imperatives of knowledge management. Specifically, operationalization of empirical measures for relevant knowledge work constructs will be seen as significant contribution to both theory and practice.

Second, national cultures, settings, and idiosyncrasies must be accounted for in future work, given that businesses increasingly span national boundaries, national cultures, and firm cultures. The link between knowledge integration and its cultural drivers potentially offers a multidimensional set of causal and reverse causal relationships that we can presently only hypothesize about. This issue is expected to be especially pronounced in teams that are cross-border in structure. Such teams might have members from various — occasionally incompatible — national and organizational cultures. When managers attempt to build 'team cultures' in such short-lived teams, can such a subculture really exist or is it merely a ghost of their imagination? The assumption of permanence that pervades organizational theories will necessarily blind researchers to the differences between temporary and relatively permanent teams.

Finally, the concept of knowledge integration *capability* deserves further development. In other words, how does a firm define, measure, and benchmark its capability to integrate distributed component knowledge into architectural knowledge. The literatures from dynamic capabilities (Eisenhardt and Martin, 2000; Khanna *et al.*, 1998; Teece *et al.*, 1997) and capability formation (Collins, 1994; Fuchs *et al.*, 2000; Helfat, 2000), especially in firm networks (Kogut, 2000) promise much insight to inform us in this endeavor.

CONCLUSIONS

Execution of e-business projects in global, cross-border environments demands effective knowledge management across previously assumed organizational and functional boundaries. Firms that master the integration of their knowledge assets are more likely to capture the potential performance, leadership, and efficiency benefits that accrue from it. Although knowledge has always played a critical role in knowledge intensive tasks such as systems development, both its influence and the difficulties in facilitating it across the cultural, national, and temporal boundaries that global teams span are likely to be more pronounced. Even though collaborative technology can assist in knowledge management, managers must comprehend the nature and extent of structural disruptions in knowledge due to the architecturally destructive nature of e-business. Such structural changes can be analyzed using the framework discussed in this paper, and appropriate responses predicted *ex ante* through

careful composition of project teams and complementary organizational mechanisms.

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