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**TITLE** Knowledge management for technological innovation in organizations: The fusion process for creating intellectual capital

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## ABSTRACT

Title of Dissertation:           **KNOWLEDGE MANAGEMENT FOR  
TECHNOLOGICAL INNOVATION IN  
ORGANIZATIONS: THE FUSION  
PROCESS FOR CREATING  
INTELLECTUAL CAPITAL**

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Management, 2006

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In a knowledge-centric economy, knowledge, embodied as intellectual capital, is increasingly a strategic resource for organizations in all areas of human endeavor. This dissertation presents an integrative conceptual framework for knowledge management that encompasses a fusion process for creating new knowledge and technological innovations in a competitive environment, using management services firms as a specific economic context for application. The framework embodies the premise that the most effective and efficient organizations are those that can learn to learn – to incorporate learning processes, including knowledge creation, into their everyday operations and management.

The theoretical foundations of the framework include multiple perspectives of knowledge formation and technological innovation, with a particular focus on conversion of knowledge from tacit to explicit forms and ultimately to intellectual capital, especially technologically embodied forms – tools, skills, facts and procedures that are the knowledge-in-use within

organizations. The framework is conceived as an organizational learning cycle or fusion process, which encompasses sub-processes for knowledge acquisition and formation, technological embodiment of knowledge, entrepreneurial application of technologies, and assessment of knowledge-in-use by an organization, in order to create or form intellectual capital.

The framework has been refined and validated through several means: (1) feedback from participants in an academic conference; (2) four case studies that encompassed interviews with practitioner professionals as well as application of the framework as an analytical framework in field studies of the associated firms; and (3) participation as an observer in an ICT solutions project as an additional case for field study of analytic application of the framework. Operationalization of the framework as a management tool is demonstrated by applying the Analytic Hierarchy Process, using comparison matrices prepared by the interviewees.

Key findings include: (1) perceptions of knowledge management definition and use vary among practitioners, even within a single industry; (2) there may be significant differences in priorities between knowledge management professionals and practicing consultants; and (3) to be actionable, knowledge developed in the organizational context must be re-assimilated by individuals, who remain the main agents of action.

*Keywords:* technological innovation; intellectual capital; knowledge management; knowledge creation; organizational learning; knowledge fusion; technoware, humanware, inforware and orgaware

KNOWLEDGE MANAGEMENT FOR TECHNOLOGICAL INNOVATION IN  
ORGANIZATIONS: THE FUSION PROCESS FOR CREATING INTELLECTUAL CAPITAL

By

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Graduate School of Management and Technology of the  
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2006

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## Dedication

To Michele, Jason and Bryan for their constant support and understanding.

To my parents, Ann and Chuck, for instilling in me the value of life-long learning.

And to my brother, Jim, for demonstrating the courage of entrepreneurship.

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## Chapter 1. Introduction and Research Question

A knowledge-centric economy presents many challenges to organizations, whether they are for-profit or not. This dissertation discusses many aspects of knowledge creation and use within organizations in order to develop an integrative conceptual framework that may be used by managers to assess and improve the management of intellectual capital. This introductory chapter outlines the challenges of a knowledge-centric economy, describes an economic sector context for the study as well as the knowledge environment within which management services are provided, and describes the research question addressed in this dissertation.

### *1.1 Challenges of a Knowledge-Centric Economy*

A shift towards a knowledge-centric economy, from a primarily industrial-age economy based on traditional mass production and generalized services, was observed four decades ago (Machlup, 1962 & 1979; Drucker, 1969; Bell, 1973). Especially the rapid growth in capabilities of information and communications technology (ICT)<sup>1</sup> has accelerated this transformation, and recently has supported the emergence of a new “digital economy,” a marketplace<sup>2</sup> that exists primarily, in some cases entirely, in the virtual world of electronic media. With the advent of the digital economy, within which businesses are highly dependent on technologies and explicit encoding of knowledge because there may be little or no “face-to-face” personal interaction, effective use of intellectual resources becomes ever more important to sustain competitive advantage. But the centrality of knowledge is not limited to the digital marketplace; knowledge,

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<sup>1</sup> The term information and communications technology (ICT) is an expansion of the earlier term information technology (IT) – this expansion emphasizes the importance of the integration of information with communications technologies in the highly networked information infrastructure which has evolved over the past half century.

<sup>2</sup> Marketplace is a term that has emerged in recent years to evoke the changed nature of the marketplace. It is intended to differentiate virtual marketplaces, which include electronic marketplaces such as those available through the Internet, from the traditional physical marketplaces. It conveys the sense of a public, open space for conducting commerce; yet recognizes that this space does not necessarily exist at one geographic location, or may be entirely a virtual marketplace with no physical location for conducting commerce at all. (cf. Rayport & Sviokla, 1994)

embodied as intellectual capital, is increasingly a strategic resource for organizations in all areas of human endeavor, including the work of governmental and not-for-profit organizations.

Development and execution of business strategies in a knowledge-centric economy can present significant resource challenges, particularly intellectual capital challenges, to an organization. Because of the limited resources within individual organizations, particularly small entrepreneurial organizations typical of new or niche businesses, it is often necessary to augment organizational resources with external resources in order to develop and execute business strategies – a number of businesses have arisen to provide this assistance, ranging from individual consultants and staff augmentation firms to providers of full solutions to business problems. While individual consultants and augmented staff typically integrate directly into projects within the organization, management services firms may take a more prominent role in shaping the conduct and outcomes of a project, even, in some cases, taking the lead role, at least from a technical perspective, because of their expertise.

However, in taking on this larger role, external management services and other providers often are presented with significant challenges in developing effective solutions in partnership with their clients. Many of these projects do not fully succeed – ranging from projects with significant cost and schedule overruns or reduced functionality, to projects that are never completed, are not accepted by the client organization, or are rejected or ignored by the ultimate customers. As one example, Sears recently sued to end a major technology services contract, citing failure to perform (Frauenheim, 2005). High profile examples can be found in the public sector as well. As examples, the Federal Bureau of Investigation's Virtual Case File project was canceled after the delivered system did not meet agency needs (Associated Press, 2005; Goldstein, 2005), and the Marine Corps terminated the Global Combat Support System contract



(Tiboni, 2006) for failure of the services provider to complete key documentation in the requirements and design stages of the systems development life cycle.

Managers of both provider and client organizations are continually seeking ways to achieve better outcomes from these solution projects. In addition to these immediate project concerns, management services firms must remain competitive in order to garner new business. Building capabilities and competencies, attracting and retaining knowledge workers, and developing innovative approaches for projects are continual challenges. Means must be found to enable effective sharing of knowledge, including organizational vision, goals, concepts and image, as well as specific subject matter knowledge. And a particular concern is how to benefit from the learning accomplished by each individual project team, especially as a project draws to a close – it continues to prove difficult to replicate the successes of one project in another, even if the project team (at least on the provider side) remains intact. The crux of the challenge may be the management of knowledge – both the knowledge within individual projects, and the knowledge maintained and used by the organizations involved in the project.

As a result, knowledge management has emerged as one of the central foci of both practice and research with regard to organizational dynamics and performance. The shift from the old, industrial economy to a new knowledge-centric economy requires companies to maximize their use of knowledge, often embodied as technologies. Nevens, Summe & Uttal (1990) and others (Wheelwright & Sasser, 1989) have found that even industrial companies compete more effectively when their products and processes are well managed, even maximized with respect to technological content. As a result, intellectual capital has become a strategic focus for the most successful businesses and is widely discussed in both academic and practitioner literature.

A large body of work exists with respect to knowledge management as it relates to managing explicit, i.e. codified, knowledge, especially in the context of ICT systems to support knowledge management, including so-called artificial intelligence. Another major research stream has been the valuation of knowledge, particularly under the moniker of intellectual capital, as well as development of various indices to aid in intellectual capital-related decisions, especially with respect to national and regional development policies (Godin, 2003). A third stream is focused on human behavior – these researchers, building on basic theories of needs and motivation, are focused on such subject areas as leadership, creativity, and entrepreneurship. Yet another stream of research is focused on business functions, where knowledge is treated in an operational context. All of the different characteristics of knowledge perceived from each of these viewpoints become fused within knowledge-in-use, which is embodied within various, often technological forms. The concern then in this paper is with the creation and use of knowledge within organizations, with what is being called the fusion process of knowledge management for technological innovation. This fusion process can be viewed as including three major integrative sub-processes, the first of which generates concepts to be applied, the second of which generates technologies – both usually with an intent for use within specific application contexts – and the third of which actually applies knowledge and technologies in decision making and problem solving.

Popper (1963) has observed that there has been a long-running debate between two views of knowledge and epistemology: (1) controlled observation – empiricism, which attempts to develop knowledge from observation of nature and was the foundation of much of scientific work during the late eighteenth through the mid-twentieth century, and (2) intellectual intuition – rationalism, which posits reasoned theory that is viable until proven wrong. In actual practice,

especially in pragmatic knowledge use in organizations, knowledge is generated by an integration of both perspectives. The fusion process being described, then, employs a pragmatic view of knowledge – knowledge must be actionable and useful within a given context. The mechanism for the creation of new knowledge is a dialectical process that integrates diverse, sometimes conflicting, tacit and explicit knowledge into new forms – the key to knowledge creation lies in mobilization and partial conversion of tacit knowledge through a process of knowledge fusion: (1) integration of discipline-based knowledge, (2) integration of knowledge at the intersection of related disciplines, (3) integration of socially acceptable beliefs, and (4) integration of tacit and explicit knowledge through conceptual charts and other modeling mechanisms (Sharif, 2005b). But, actionable knowledge that results from this first fusion process is still only a potential resource.

In order to bring knowledge to the marketplace, in the next stage knowledge must be integrated with other resources available to the organization, generating technological innovations, both internally (organization) and externally (market) oriented. Sharif (1988) has partitioned technological embodiments into tools, skills, facts, and procedures, and has coined the terms technoware, humanware, inforware, and orgaware, respectively. Such a partitioning of technology facilitates managing the fusion process, as well as ongoing assessment of organizational knowledge creation – successful innovation can be measured by observing growth and change in each technological type, as well as shifts in emphasis among them over time (e.g., relative levels of investment or use).

The focus in this paper is on how knowledge management involves a fusion process that joins individual and group knowledge from many sources, and integrates this knowledge with other resources to generate technological innovations, in ongoing cycles of organizational

learning, technological development, action, and assessment with the goals of sustainability, competitiveness, efficiency and effectiveness – including, for commercial enterprises, profitability.

### *1.2 Economic Sector Context*

Before discussing in detail the knowledge fusion process, it is useful to establish a specific economic sector context, knowledge-centric management service providers, which can serve as a frame of reference for discussion and a source for examples.

#### *1.2.1 Knowledge-Centric Organizations*

Knowledge-centric organizations are a special subset of knowledge-intensive firms, a term prevalent in the literature for firms whose focus of activity is on knowledge exploitation. Starbuck (1992) defines a knowledge-intensive firm as one whose primary input resource is knowledge, relative to other key inputs such as capital and labor. All firms are dependent on knowledge (Prusak, 1998), but use of knowledge by firms can be considered as falling within a spectrum from relatively low knowledge content (for example a firm involved in extraction processes such as timber harvesting) to highly-intense knowledge content (for example a “think tank”) – differentiation is manifest in how knowledge is used by the firm. But even the timber company begins to move further along the knowledge continuum as soon as it progresses from simple logging of existing forests to more sustainable strategies such as tree farming. Another dimension of interest, closely related, is the knowledge content of the output of the firm, viewed from the perspective of the customer’s ability to expand their stock of knowledge. It is from this perspective of knowledge that the knowledge-centric firm is defined.

A knowledge centric firm is, then, a knowledge-intensive firm whose primary output to the market has a high knowledge transfer component. In many cases, the primary economic

purpose of a knowledge-centric organization is to provide knowledge, often in the form of subject matter expertise; some of the value propositions being the offering of experts, quality of research, specific competencies, and innovative means of delivery. The most obvious examples of such firms, considering commercial enterprises, are a subset of professional business service, also known as management service, firms (McKaig-Berliner, 2001) – a subset because, while all of these firms have knowledge-based outputs, some of them are merely conduits for individual expertise, sometimes even at as primitive a level as staff augmentation for the customer. Knowledge-centric firms, on the other hand, are posited to hold knowledge competencies at the organizational level. Such firms may offer, in addition to expert consulting, other knowledge outputs such as knowledge bases and associated services or publications.

Sveiby (1997, pp ix-x) observes that managing knowledge-centric companies differs significantly from managing traditional manufacturing firms. He notes that this is reflected, for example, in the inadequacy of traditional accounting to reflect accurately the value of a business. Managers of knowledge-centric firms must be concerned with managing invisible knowledge-based assets: experts, concepts, image, and networks.

### 1.2.2 Management Services Organizations

Management service organizations provide expert services to enterprises in order for those enterprises to pursue management strategies and objectives that would otherwise be unachievable without using external resources, or at a minimum, without the validation from independent review. At the core of such business relationships is a sharing of knowledge, sometimes as expertise of individual practitioners, but also as complementary competencies. It is in this latter sense that these firms are of particular interest; and, when looking for examples during this research, selections primarily have been drawn from a specific subset of management

services organizations: ICT solution providers. ICT solution providers aid client firms in applying information and communications technologies to solve business problems and exploit opportunities in the market. Support may range from providing consultative advice to providing full ICT solutions such as outsourcing of computing and communications infrastructure and software applications.

### 1.2.3 The Organization as a System

Senge (1990, pp. 3-7) suggests that understanding an organization as a system is an essential prerequisite to transforming the organization into a true learning organization; otherwise, in concentrating on isolated phenomena, the full picture cannot be seen – knowledge may remain incomplete or narrowly focused. And, if an attempt is being made at problem solving, the solutions may become the problem through unintended consequences, often the result of not understanding the intricacies and interplay of the full system. These observations are echoed by Gharajedaghi (1999, p. 123): “We are less likely to be able to explain the behavior of a complex whole by studying the behavior of the parts; contrarily, we are more likely to explain the behavior of the parts by studying the behavior of the whole.” Gharajedaghi places particular importance on understanding the interactions or relationships among the elements of a system, suggesting that management of a system “is more and more about managing its transactional environment...” (p. 51). He also emphasizes the importance of understanding the system in context: “the behavior of living (open) systems can be understood only in the context of their environment,” (p30) and “... a structure cannot completely explain its outcome and why we need the additional concept of an environment as a coproducer. ... Structure, function, and process, along with the environment, form an independent set of variables. Together they define

the whole, or make possible the understanding of the whole” (p112) – “Neither problems nor solutions can be entertained free of context.” (p116)

The idea of an organization as a living system is reflected in the work of Nonaka & Toyama (2002), who treat the firm as a “dialectical being” that creates knowledge through a process of resolving contradictions (p995). In the fusion model, this dialectical process is expanded to encompass the fusion of varying perspectives of knowledge and technology as well as diverse subject areas of knowledge.

### *1.3 Knowledge Sources for Management Services Projects*

In order to better understand knowledge management, it is useful to consider the specific knowledge context for management services during the ensuing discussion. As outlined in Figure 1, the knowledge sources for providing knowledge-centric services transcend any individual organization, drawing from sources both internal and external to the organizations participating in the project. Particularly for small knowledge-intensive organizations, the breadth and depth of knowledge areas required to support a typical customer engagement force many organizations to look outside to supplement their own capabilities and competencies. As with other organizational resources, growth of an organization may lead to increasing internalization and integration of knowledge resources along both horizontal and vertical dimensions. Also, the customer is a critical source of knowledge, and may even (probably ideally does) contribute resources to the project team. It may be that under the ideal scenario, the provision of knowledge-centric services involves mutual learning processes between the provider and the client. The following summarizes the knowledge sources for the project:

- (1) Project knowledge areas: the participants in the project team are the immediate source of knowledge used in the solution. While the team may comprise mostly people from the

provider organization, usually there are representatives of the client organization who carry knowledge specific to the client. There also may be independent specialists on the team to provide knowledge in various technical, managerial or market subjects.

- (2) Provider: The provider organization is the primary conduit for knowledge specific to the management services being provided. They often take the lead or share in the project management.
- (3) Client: The client organization is the primary conduit for knowledge of context-specific strategies and management and business requirements, including those coming into the project from the customers of the client, the client's industry cluster, and the economy and society at large.
- (4) Communities of interest: Many people involved in the project will be able to draw on knowledge from networked sources such as peers and professional organizations.
- (5) Customers of the client: The needs and desires of end customers are ultimately a critical element in the project. These needs and desires may be conveyed to the project team by the client organization, there may be direct representation of customers on the project team, or there may be specific project activities to collect customer-related knowledge.
- (6) Industry cluster(s)<sup>3</sup> of the provider: The provider organization will sit within one or more industries from which knowledge will be drawn, such as standards, best practices, and other norms as well as knowledge of evolving technologies, trends and other information useful in developing innovations.
- (7) Industry cluster(s) of the client: Similarly, the client organization will be drawing knowledge from the industry cluster(s) within which it sits.

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<sup>3</sup> This concept comes from Porter (2000). See the discussion in 2.2.3 *Environmental Conditions for Innovation*.



(8) Economy and society: The overall economic, social and ethical context for the solution, including opportunities and limitations, is defined by the economy and society at large. Cultural norms will have a strong impact on project team behavior. The project team may need to integrate disparate cultures, especially in a multinational context. And, in the digital economy, especially business over the public internet, any organization may have a global presence.

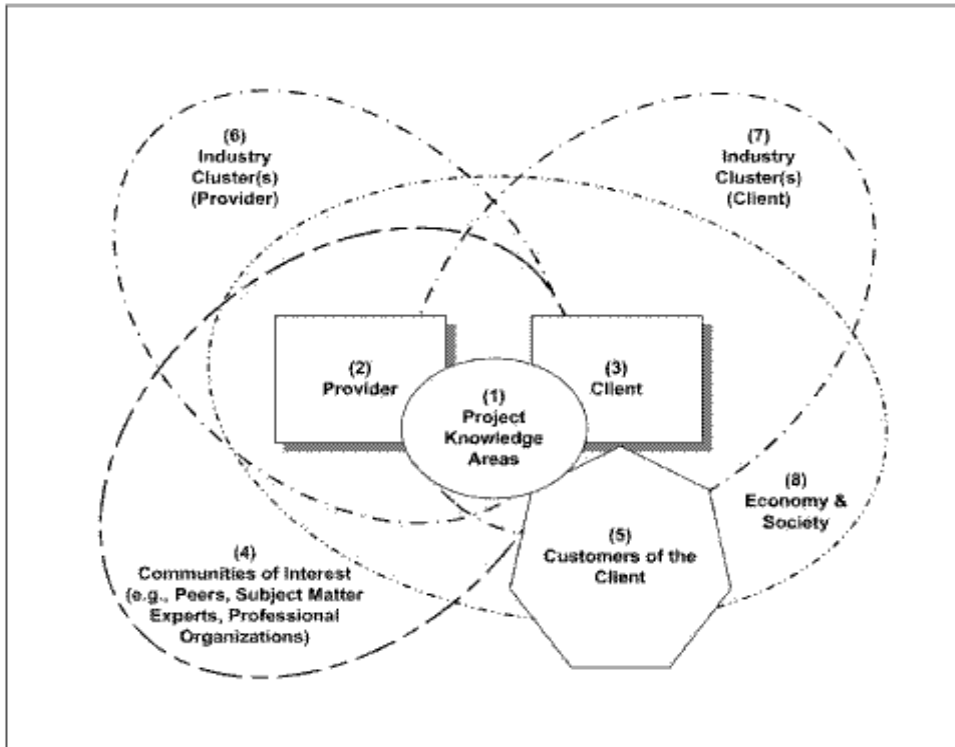


Figure 1. Knowledge context for management services projects

These diverse sources of knowledge, required to bring the project to a successful conclusion, create a complex environment for executive and project managers. As an example,