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The theoretical foundations of knowledge management

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Abstract
Knowledge management has emerged as an important field for practice and research in information systems. This field is building on theoretical foundations from information economics, strategic management, organizational culture, organizational behavior, organizational structure, artificial intelligence, quality management, and organizational performance measurement. These theories are being used as foundations for new concepts that provide a rationale for managing knowledge, define the process of managing knowledge, and enable us to evaluate the results of this process. Based on articles published between 1995 and 2005, new concepts are emerging, including knowledge economy, knowledge alliance, knowledge culture, knowledge organization, knowledge infrastructure, and knowledge equity. An analysis of the theoretical foundations of knowledge management reveals a healthy arena with a strong foundation and clear directions for future work.
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Introduction

Knowledge management is a field that arose with rapid practical intellectual strength for management. It only achieved management 'buzzword' status in the past decade, (Shoesmith, 1996), and was in common use by human resource managers by 1997 (Benson, 1997). Within this very short period, virtually every executive was characterizing their most important responsibility as 'leveraging organizational knowledge' (Ruggles, 1998, p. 89). Such practical and intellectual impact does not arise so quickly without rigor and strength in the theoretical foundations. The purpose of this paper is to provide an analytical survey of the way previously established theories are used as a foundation for knowledge management. In fact, the theory of knowledge management amalgamates a cluster of theories from existing research fields into a consistent foundation for a field with unique directions and innovative concepts of its own. The linkage of knowledge management to its underlying theoretical foundations clearly illustrates how this field has been systematically raised into a distinctive, important and practicable body of management theory.

Understanding how pre-existing theories have been used to build a developing field such as knowledge management is important because these theories substantiate and legitimate the field as a field of science. Together with methods and aims, theories are a key part of any field's claims to scientific rationality. Theories harmonize research aims that justify methods used in turn to justify the theories themselves (Laudan,

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1984). Taken as a whole, this triad is the essential justification of research (Robey, 1996). If knowledge management theories had emerged solely from artificial intelligence theories, then the legitimacy of the newer field would be based solely on the legitimacy of the older. If instead knowledge management theories emerged from a broad range of other fields, its legitimacy as a field of science would be broader and stronger. By tracing the foundations of the theories used in knowledge management, we demonstrate the value of its scientific rationality. The following sections trace the evolution of the term 'knowledge management' with regard to its definitions and the kinds of knowledge. After that, the focus shifts to existing knowledge management frameworks and to an important expansion of this research stream, namely a detailed taxonomy of the knowledge management literature based on related theories borrowed from other disciplines. Finally, the last two sections offer a brief discussion on the relationships among the new knowledge management theories and some conclusions about the knowledge management field.

Definitions of knowledge

Improvements in knowledge management promote those 'factors that lead to superior performance: organizational creativity, operational effectiveness and quality of products and services' (Wiig, 1993, p. xv). An understanding of the way the term has evolved in the literature begins with the untangling of the confusing links to at least two important information systems (IS) concepts previously housed within the boundaries of other specialized IS fields. The first concept regards knowledge-base management within the field of expert systems (e.g., Zeleny, 1987). The other concept regards the management of knowledge as an organizational resource, this usage appearing as early as 1989 in the management literature (Adler, 1989). A working definition of this broader view of organizational knowledge is 'information embedded in routines and processes which enable action'. Knowledge is an innately human quality, residing in the living mind because a person must 'identify, interpret and internalize knowledge' (Myers, 1996, p. 2).

Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of 'knowers'. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms. (Davenport & Prusak, 1998, p. 5).

Kinds of knowledge

Information consists of 'facts and data that are organized to describe a particular situation or condition'. Knowledge is distinguished from information by the addition of 'truths, beliefs, perspectives and concepts, judgments and expectations, methodologies, and know-how' (Wiig, 1993, p. xvi). Nevertheless, knowledge can also become information once it is codified in symbolic forms such as text, charts, or images, etc. (Alavi & Leidner, 2001).

Organizational knowledge is variously analyzed at different levels of abstraction for the purpose of management. One simple analysis distinguishes information (know-what) from combinational skill (know-how) (Birkett, 1995; Kogut & Zander, 1997), useful for differentiating basic management techniques for passive, stored knowledge from those best suited for managing dynamic knowledge of process. A similar distinction separates technical knowledge and innovation research from tacit knowledge, personal skill, and organizational routine (Tordoir, 1995). Another distinguishes tacit knowledge from articulated knowledge (Hedlund, 1994; Nonaka & Takeuchi, 1995), useful for separating the various management processes for enabling the transfer of knowledge. Another distinguishes professional knowledge from firm-specific knowledge (Tordoir, 1995), important for determining whether to 'make' or 'buy' knowledge. Yet, another distinguishes scientific, philosophical, and commercial knowledge (Demarest, 1997), useful for managing the goals of the knowledge production process, each type embodying different goals such as knowledge conventions, truth, and effective performance.

As the practice of knowledge management developed through the first years of the new millennium, the distinction between knowledge and information grew vague. Undeterred by accusations of 'search and replace marketing', many aspects of IS and information technology have been variously mislabeled as knowledge management (Wilson, 2002). Seeking to distinguish the original knowledge concept, many authors were driven to identify new terms such as 'experience management' (Bergmann, 2002) or 'expertise sharing' (Ackerman *et al.*, 2003).

These hazy distinctions can create boundary problems beyond the concept of knowledge itself, clouding the distinction between knowledge management research and the other fields of research that underlie it. For practical reasons, we must ultimately rely on the words of the researchers themselves, and trust them to label 'knowledge management' as such, thus giving us a reasonably clear boundary line by which to distinguish knowledge management from other intellectual fields that may be distinct from, but related to it. For example, complexity theory could be used to explain knowledge management systems. However, it is important to distinguish 'knowledge management' from the underlying 'complexity theory' rather than conflate the two fields. With hopes that the original distinctions described above will prevail, this paper will continue to use 'knowledge' and 'knowledge management' as described in the seminal literature.

Knowledge management frameworks

The veritable explosion of knowledge management in the business scene has left many authors struggling to make sense of the large contemporary body of highly diverse work. Studies have examined published research about

the kinds of roles imputed to information technology for knowledge management and knowledge creation in organizations (e.g., Alavi & Leidner, 2001; Marwick, 2001). Other work has analyzed the various management techniques proposed and described in the literature that seem applicable to knowledge management (e.g., Dieng *et al.*, 1999; Kannan & Aulbur, 2004). Much of this sense-making seeks to frame knowledge management research. It exposes the trendy projection of such conceptual predecessors as organizational learning and business process re-engineering, and how these fields are developing into knowledge management (e.g., Streatfield & Wilson, 1999; Scarbrough & Swan, 2001; Scholl *et al.*, 2004). It also examines the unrecognized consequences of knowledge management research and exposes the need for broader intellectual foundations such as entrepreneurship and culture (e.g., Teece, 1998; Rubenstein-Montano *et al.*, 2001; Zhu, 2004). These frameworks also look at the underlying structure of this research including knowledge as a process, knowledge sharing as a transaction, and the schools of knowledge management that regard these research structures (e.g., Earl, 2001; Grover & Davenport, 2001; Schultze & Leidner, 2002).

The particular importance of strategy research as a foundation for knowledge management led to a knowledge-based theory of strategy (Eisenhardt & Santos, 2002). This work unveils the roots of certain knowledge management concepts such as organizational learning, innovation, tacit knowledge, and core competencies. However, the scope of this work remains focused on the field of strategy.

A recent editorial in the *KMRP* journal presented the foundations and the future directions of the knowledge management field, based on the opinions of a small sample ($n = 25$) of KM experts (Edwards *et al.*, 2003). Expanding the main ideas from that editorial, the central contribution of this article is to develop a detailed taxonomy that illustrates how knowledge management has drawn its ideas from a wide variety of other intellectual fields. In this way, we learn about the substantial intellectual value that knowledge management is adding to its forebears.

Roots and flow of related theories

In order for us to establish an evolution of knowledge management theory, we must explicate the theories at work in the field, and the sources underlying the development of the theories. To be regarded as theories, there must be more involved than just data, variables, constructs, or diagrams. Unfortunately, there is substantial disagreement about what constitutes theory. For some, theory explains the connections between phenomena (Sutton & Staw, 1995). For others, it should intellectually clarify (DiMaggio, 1995) or engage (Weick, 1995). We certainly cannot resolve this debate in this paper. However, for our purposes, we take a moderately broad view of the constitution of theory: something more substantial than a static construct. In particular, we look for unique concepts in application: concisely labeled ideas with some rigor and a dynamic quality in their use. Perhaps, these uses are in models, explanations, or interpretations.

Our approach follows simple systematics procedures (McKelvey, 1982). Unlike functional science, which is the study of uniformity in nature, systematics is the study of diversity. Rather than search for natural or probabilistic laws, systematics is used to study taxonomy, evolution, and classification. There are two basic activities: tracing and taxonomy.[1] Taxonomy involves uncovering the processes by which the theories evolve, while tracing involves both the identification of similar theories and the search for commonalities in their origins. The two activities are interactive rather than sequential. The approach allows us to cluster theories from existing research fields and explore similarities in the process (the purpose) by which the theories were adopted or adapted.

Taxonomies are interpretations of reality, and should be viewed as sense-making structures imposed on reality, rather than inherent in nature. For example, biologists classify whales and bats together as mammals instead of with fishes or birds. This is because they are more concerned with the biological processes rather than the selected environment or natural behavior (Goldstein, 1978). In our case, we provide a taxonomy based on the purposes (the processes) used for drafting knowledge management's theories from those in other fields.

Our tracing involved using library resources such as electronic catalogues, ABI Inform, and the Web of Science database. We searched for scholarly manuscripts published between 1995 and 2005[2] that had 'knowledge management' in the title, in the abstract, or as a keyword or subject.[3] We manually scanned the abstracts of each paper and the introductory chapters of each book, and selected all manuscripts that appeared directly relevant to the stream of development in knowledge management. This relevance was determined by the number of citations, contribution, and novelty of the research question. The resulting sample contained 135 articles, published in 61 journals (see Appendix 1 for journal distribution), and 47 books. Then, each article and each book were read by at least one of the authors in order to identify durable and clearly defined theories in know-

[1]McKelvey also called these 'Phyletics' and 'Speciation', respectively.

[2]Knowledge Management publications appeared even before 1995. According to the ABI Inform database, their total number is around 57 publications, while just in 1996 alone there were 59 publications. Therefore, we decided to set 1995 as the starting point, which is consistent with other studies (Wilson, 2002).

[3]While keywords such as 'organizational learning', 'knowledge transfer', or 'knowledge sharing' could also have been used, we ultimately relied on the researchers to use the term 'knowledge management' at least as a keyword and on librarians to label such work in the broader 'knowledge management' category. This reliance on researchers' and librarians' definitions is not without risk. A limitation incurred with this approach includes the distortion of such definitions of Knowledge Management that may result from the imperative to publish.

ledge management (i.e., not just knowledge management buzzwords) that were novel. When a theory was present in multiple articles, we included only the first cited article. This reduced the final sample to 74 articles from 38 journals (see Appendix 2 for final sample journal distribution) and 25 books (see Appendix 3 for final sample book list). From this reading, we developed an emerging list of theories arising from this body of scholarly work that were directed toward advancing knowledge management.

We avoided characterizing the books and articles themselves; rather we used an exploratory approach that enabled us to trace similar theories, as these appeared in the selected literature, back to their models in the referenced literature. Using this trace, similarities in character in the reference literature emerge, along with similarities in the way that the theories are generally used within the referenced knowledge management articles. This usage then suggests the purpose for the development of the knowledge management concept, and helps us to understand the process by which the theories were drawn (such a process is a key aspect of taxonomy).

Table 1 outlines the flow of theory into the knowledge management field from other research fields. It is possible to analyze the purpose of this flow according to the application of these theories within knowledge management, thus developing new theories. For example, in Table 1, early development of the theories of knowledge economy referenced intellectual capital and intellectual property from the information economics literature. Why? The knowledge economy provides important aspects of the rationale for managing knowledge. By clustering the theories that draw from this rationale, both the evolution of ideas and their corresponding process emerge.

These new theories are of interest to those working in the foundation fields as well as to the knowledge management specialists. The proposed taxonomy applies to the particular theories in use, not to the selected articles. Many academic manuscripts draw on multiple theoretical foundations for multiple purposes. Where referenced, the articles represent specimen locations in which the theories arise, but are not necessarily seminal or solely dedicated to any one particular theory.

The remainder of this paper is organized following the purposes that ultimately define this taxonomy, as are outlined in Table 1. The next section focuses on theories considered as the rationale for the knowledge management field, the subsequent section focuses on the theories that underlie the various knowledge management processes, and the final section discusses another major research arena: measurement theories.

Rationale underlying knowledge management

At least three theoretical concepts motivate knowledge management. Two of these evolve from the work in information economics: intellectual capital theory and intellectual property theory, important for valuing 'soft' organizational assets in accounting and business law. The third theoretical concept evolves from organizational strategy research: core competence management. These viewpoints from work in economics and strategy have led to theories that explain why knowledge management is important. Consequently, knowledge management is extending theories from these two fields with ten distinct theoretical concepts.

Information economics

Intellectual capital

This legal concept embodies a theory that emphasizes the value of knowledge within the organization. The physical capital of an organization, particularly in the rising service sector, is of less relative importance for competitive advantage than intangible assets like know-how and personal sales networks. The market value of many service organizations is far too much larger than the value of their physical capital to be characterized as 'goodwill' (Roos & von Krogh, 1996). Intellectual capital has been defined as the difference between the book value of the company and the amount of money someone is prepared to pay for it. Intellectual capital theory is about assets: assets like trademarks and customer loyalty that give the company power in the marketplace; assets like patents and copyrights that give the company property rights 'of the mind'; assets like corporate culture, structure, and IT style that give the company internal strength; and assets like employees' knowledge and personal networks that enable company processes (Brooking, 1997). Organizational knowledge is viewed as a capital asset. This view implies that knowledge management regards balancing a knowledge portfolio. Thereafter, the portfolio is coordinated and exploited for maximized return-on-investment (Wiig, 1997a).

Intellectual property

The rationale determined by intellectual capital theory drives the need to account for knowledge, and the need for 'due care' in managing it. Intellectual property theory encompasses the legal and ethical issues of intellectual capital, such as copyrights, patents, trade secrets, and other proprietary rights (Slater, 1998). There are few techniques for assigning a monetary value to organizational knowledge, even to the more concrete technical knowledge (Bohn, 1994). There is also concern that poor knowledge management poses dramatic, yet unaccounted risks to organizations (Marshall *et al*., 1996). Hence, these essential accounting needs, plus quality-driven management, motivate the need to measure and manage organizational knowledge, a separate field discussed later in this paper (see section 'Knowledge measurement').

Knowledge economy

This theoretical concept is developing out of concern for knowledge management, and is an important extension to information economics. It essentially regards the 'product life cycle' of knowledge, applying this to either an internal market within an organization or to the

Table 1 The flow and use of Knowledge Management (KM) theory with examples

Applied purpose in KM	*Theoretical foundation*	*Key theories drawn from this foundation*	*Developed key KM theories*	*Examples of theories as applied in KM*
Rationale	Information economics	Intellectual capital, intellectual property	Knowledge economy, knowledge networks and clusters, knowledge assets, knowledge spillovers, continuity management	Tordoir (1995), Inkpen & Tsang (2005), Teece (2000), Foray (2004), Beazley *et al.* (2002)
	Strategic management	Core competencies, dynamic capabilities	Dumbsizing, knowledge alliances, knowledge strategy, knowledge marketplace, knowledge capability	Conner & Prahalad (1996), Eisenberg (1997), Inkpen & Dinur (1998), (Conner & Prahalad (1996), Kafentzis *et al.* (2004), Baskerville & Pries-Heje (1999)
Process definition	Organizational culture	Cultural values, power, control and trust	Knowledge culture	Graham & Pizzo (1996), De Long & Fahey (2000)
	Organizational structure	Goal-seeking organizations	Knowledge organizations	Starbuck (1997), Dyer & Nobeoka (2000)
	Organizational behavior	Organizational creativity, innovation, organizational learning, organizational memory,	Knowledge creation, knowledge codification, knowledge transfer/reuse	Nonaka & Takeuchi (1995), Nonaka & Toyama (2003), Wiig (1995), Hansen *et al.* (1999), Markus (2001)
	Artificial intelligence	Knowledge-based systems, data mining	Knowledge infrastructure, knowledge architecture, knowledge discovery	Davenport *et al.* (1998), O'Leary (1998b), Zhuge (2002), Fayyad *et al.* (1996), Shaw *et al.* (2001)
Evaluation	Quality management	Risk management, benchmarking	Knowledge equity, qualitative frameworks	Glazer (1998), Jordan & Jones (1997), King & Zeithaml (2003)
	Organizational performance measurement	Financial performance measures	Performance indices	Ahn & Chang (2004), Chang Lee *et al.* (2005)

external (consulting) marketplace, a commercial market for professional knowledge. From this perspective, managing the knowledge economy within an organization is important because professional knowledge is a valuable commodity. According to knowledge economics theory, there are several important management decisions that are directly informed by the knowledge economics rationale. One decision, for example, is determining how and when to develop professional knowledge internally and under what circumstances it is more attractive to use external experts. Another decision regards how internal knowledge should be combined with external knowledge, that is, consultants. Finally, there is a decision regarding both how and when internal knowledge should be marketed externally. Consulting firms are particularly interested in the knowledge economy, since their product is developed and marketed here.

Knowledge economy theory describes the need for 'professional support' in organizations. The basic functions of professional support include communication with the environment, reduction of complexity and risk, coordination of the routine tasks issuing from reduced complexity, and standardization, adaptation, and improvement of such routines. Professional or commercial knowledge is necessarily characterized by heuristics based on four elements. These elements are universal, scientific knowledge, routinized skill based on deep practical experience, judgment for optimizing the further use of experts, and capacity for decomposing a unique, complex task into a set of routine, simple tasks (Tordoir, 1995).

Knowledge economy theory is concerned with the production and distribution of knowledge as a commodity for consumption within the organization's value chain. It is also concerned with knowledge as a direct product of the value chain to be marketed outside the organization. For example, one mechanism for managing the knowledge economy involves implementing a generic knowledge management life cycle. Knowledge management is divided into four iterative processes: (1) construction, discovering or structuring of a class of knowledge, such as a methodology; (2) embodiment, choosing a 'container for knowledge, such as a document; (3) dissemination, human or technical processes that make the embodied knowledge available in its market; and (4) use, production of commercial value for the customer (Demarest, 1997).

Knowledge assets

Knowledge assets are 'firm-specific resources that are indispensable to create values for the firm' (Nonaka *et al*., 2000, p. 20). Knowledge assets therefore develop as the evolving inputs and outputs of knowledge activities and when used by someone other than their original creator (Baird & Henderson, 2001). Such examples concern not only organizational processes but also unconscious cultural knowledge (Boisot, 1998). Indeed, it is extremely important to know the appropriate dress code for a certain professional event or at what point of the negotiation an agreement should be put on paper without offending the other party. The management of knowledge assets builds on other concepts such as knowledge economy and knowledge strategy (Nonaka *et al*., 2000; Teece, 2000).

Knowledge clusters and networks

From a macro perspective, knowledge economic theory applies not to a single economy, but to fragmented knowledge economies. Clusters and networks emerge among organizations partnering to develop a competitive concentration of resources. Knowledge networks occur in multiunit companies and partnerships for the purpose of knowledge sharing (Inkpen & Tsang, 2005), and such sharing declines with increasing network length (Hansen, 2002). In terms of knowledge sharing, clusters are collaborative modes of business practice that enhance competitiveness because the knowledge sharing network upgrades skills and knowledge more quickly (Cooke, 2002, p. 125). The production and distribution of knowledge is segmented within these clusters, and the transfer of knowledge assets between clusters is rather different than transfers of knowledge within the clusters. The clusters develop more than knowledge capital; they develop learning capital, an asset representing the facility to rapidly upgrade skills and knowledge. As a result, the movement of knowledge assets is growing faster within economic clusters than other kinds of goods and services in the economy as a whole.

Knowledge spillovers

Networks and clusters lead theorists to recognize that the knowledge economy is a semi-public good. Fast, widespread diffusion of knowledge advances common wealth in society. Knowledge 'spillovers', the absorption of knowledge by people other than the originators, occur because knowledge is an inexhaustible, cumulative good that is difficult to control (Foray, 2004). While there may be fragmented and localized knowledge networks, spillovers inevitably create an innovative geography of varying knowledge production and transfer costs. As the overall costs of such production and transfer rise and fall across this geography, economic advantages, along with concomitant social advantages, are reapportioned.

Continuity management

Continuity management regards the preservation of corporate knowledge so as to endure employee turnover with minimal or limited organizational knowledge loss. Continuity management is the intellectual capital basis that motivates knowledge managers to facilitate knowledge transfer among organizational members and to diversify organizational memory beyond single individuals as retainers. Pathological organizational behaviors arise when key members, people who are the single repositories for critical knowledge capital, choose to depart the organization. For example, knowledge hoarding can be used to create job security or knowledge

stuffing can result from overloading a replacement with too much knowledge. Knowledge networks can be disrupted when a critical individual leaves without re-establishing an adequately prepared replacement 'node'. From a practical perspective, continuity management involves applying many of the concepts below, such as knowledge assessment and transfer, but motivated by the need to diversify knowledge across individuals to the degree that a reasonable degree of employee turnover does not disrupt operations (Beazley *et al.*, 2002).

Strategic management

Strategic Management theory determines a second category of theory that is motivating knowledge management. This view regards knowledge as a fundamental resource that enables organizations to compete more effectively in their markets (Earl, 1997). According to this body of theory, there are two key knowledge themes leading to this rationale: competence-based competition and dynamic capability. The knowledge management field is extending these strategy theories to include new concepts like dumbsizing, knowledge alliances, knowledge strategy, knowledge marketplaces, and knowledge capability.

Core competencies

Competence-based competition sees organizational competencies as a key resource under established resource-based theories of the firm. These theories of modern competition emphasize the importance of organizational 'core competencies' (Prahalad & Hamel, 1990). Core competencies span several businesses and products within a corporation. They evolve more slowly, and arise through collective learning within the firm. Competence-based competition centers these core competencies in the competition between organizations, making competition a 'contest for acquisition of skills' (Sanchez *et al.*, 1996, p. 3). In this new competitive environment, knowledge management developed important practices in order to create and maintain organizational core competence (Sanchez & Heene, 1997a, b).

Dynamic capabilities

Drawing upon a diversity of research areas such as research and development (R&D) management, technology transfer, intellectual property, new product development, human resources, and organizational learning, the theory of dynamic capabilities refers to the source of competitive advantage that companies use in situations of rapid and unpredictable change (Teece *et al.*, 1997). In such dynamic and demanding markets, it is hard to quickly and continuously transform organizational processes. Hence, managers use the firm's dynamic capabilities to integrate and recombine resources in order to create new competitive strategies. However, dynamic capabilities are necessary, but not sufficient to create a competitive advantage (Eisenhardt & Martin, 2000) and other firm-specific assets are needed such as absorptive capabilities whose supporting role enhances the transfer of knowledge (see section 'Knowledge transfer/reuse'). With regard to knowledge management, having strong dynamic capabilities to seize strategic opportunities is a key element in developing knowledge capabilities and knowledge assets (Teece, 2000).

Dumbsizing

Dumbsizing is an extension to strategic theory that is well explained by knowledge management. It refers to the damage done to organizational knowledge assets through careless re-engineering. Corporate re-engineering implies rapid, non-linear change, sometimes disregarding critical factors like knowledge management. Knowledge is largely a human property, and the damage to human systems under re-engineering could undermine sustainable profitability. Important knowledge management factors that are sometimes damaged in re-engineering include reduced R&D, deteriorated teamwork, crippled professional support, and decreased creativity (Eisenberg, 1997). The layoffs increase knowledge risk by eliminating redundancy in knowledge and destroying networks that are important for organizational resilience (Inkpen, 1996). The survivors' ability to create and transfer knowledge is often limited because they are encumbered by long working hours and increased job stress.

Knowledge alliances

Knowledge alliances are an extension to strategy theory adapting the established ideals of strategic alliances. In knowledge alliances, however, the focus is on knowledge rather than resources. These alliances motivate management to enter into strategic alliances with other firms in order to balance knowledge deficiencies, obtain necessary competencies, or create new knowledge. Knowledge alliance theory, like competence-based competition evolves from resource-based theories of the firm (Conner & Prahalad, 1996). Such firms are dynamic systems of processes involving different types of knowledge (Inkpen & Dinur, 1998). A strategic decision to correct knowledge deficiencies through alliances is a more subtle decision than merely a make-versus-buy knowledge choice. Knowledge deficiency includes the lack of organizational knowledge and knowledge-processing diversity. This lack correlates with the presence of a 'dominant logic' in organizational top management, a concept drawn from strategy research. The presence of a dominant logic results in a routinized or customary management logic that inhibits management adaptation and innovation (Bettis & Prahalad, 1995). Knowledge alliance theory, like intellectual capital theory, also entails a measurement problem. It is necessary to identify knowledge deficiencies within the firm, and knowledge strengths of potential partners and competitors. Benchmarking (see section 'Benchmarking') is a notable approach that has been applied for solving this problem, identifying within other firms industry best practices that have led to superior performance (Drew, 1997). Knowledge alliances are also motivated by inter-organizational synergy, the

ability for organizations to couple their knowledge competencies, offsetting their knowledge deficiencies, thereby enabling new knowledge creation and diffusion processes (Inkpen, 1996).

Knowledge strategy

Building from knowledge alliances, new concepts focused on multinational corporations (Almeida *et al.*, 2002) and knowledge networks (Inkpen & Tsang, 2005). A resource-based theory of the firm was developed as a marginalized strategic theory regarding knowledge in order to contrast it with a knowledge strategy (Conner & Prahalad, 2002). This knowledge strategy is then positioned as a knowledge-based theory of the firm (Eisenhardt & Santos, 2002; Grant, 2002). Because knowledge strategy seeks to diminish boundaries, it builds on other key ideas from knowledge economics as well, such as knowledge clusters and knowledge spillover.

Knowledge marketplaces

The concept of knowledge marketplaces arises from strategies for developing core competencies in e-commerce (Kafentzis *et al.*, 2004). Electronic knowledge marketplaces are virtual environments, perhaps web-based, where buyers and sellers meet to exchange products and services that are knowledge-based. These often entail intellectual property (like copyright material, patents, and designs), recruitment, consulting, and research. Knowledge e-marketplaces evolve in three ways: (1) knowledge e-marketplaces trade knowledge as a documented form independent from its owner; (2) knowledge e-marketplaces trade knowledge between individuals who communicate using various online and off-line mediums; and (3) hybrid forms of the previous two ways. Concepts and issues that develop include intelligent matchmaking, development of commonly accepted quality ratings, and fair-pricing mechanisms. Here we also find motivation for further work in developing better measurement of knowledge assets.

Knowledge capability

The concept of 'Knowledge capability' draws on research fields such as dynamic capabilities and absorptive capabilities and also builds on other knowledge management concepts such as knowledge assets and knowledge strategy. Although the terms Knowledge capabilities and Knowledge assets are sometimes used interchangeably, they are indeed different: knowledge assets may create a competitive advantage, but they are not sufficient to maintain this advantage in the absence of a knowledge capability (Venkatraman & Tanriverdi, 2004). Furthermore, in contrast to knowledge assets, which can be bought by means of mergers and acquisitions, capabilities must be built (Teece & Pisano, 2003). The development of effective knowledge capabilities supports key aspects of organizational performance measurement (Baskerville & Pries-Heje, 1999; Gold *et al.*, 2001).

The knowledge management process

The knowledge management process is necessarily loose and collaborative because knowledge is recognized to be fuzzy and messy (Allee, 1997). It is also a difficult process because the human qualities of knowledge, such as experience, intuition, and beliefs, are not only the most valuable, but are also the most difficult to manage and maximize (Davenport & Prusak, 1998). The knowledge management process integrates theories from at least four distinct fields. First, theories about organizational culture, for example, tacit and articulated knowledge, are applied in the development of the concept of a knowledge culture. Second, organizational structure theories are used to develop ideals for knowledge organizational structures. Third, established work in organizational behavior supplies theories of innovation, learning, and memory for new knowledge management concepts regarding knowledge creation and codification. Fourth, work in knowledge-based systems (KBS) (within the research field of artificial intelligence) leads to theories about knowledge-support infrastructures.

Organizational culture

Because knowledge is innately human, knowledge management educes heavily from theories dealing with organizational culture. Particularly centered are theories regarding the storage and transfer of knowledge, in particular organizational cultures. Manipulation of knowledge is an essentially human process that cannot be separated from culturally based interpretation and reflection.

Cultural values

According to Schein (1985), cultural values are an important mechanism through which an organizational culture reveals its presence. They are a reflection of the underlying cultural assumptions and they correspond to a set of social norms defining social interaction and communication in a particular context. Therefore, cultural values have an impact on the behavior and the attitude of the organizational members. When cultural values have been shared for long enough, culture becomes a product of group experience (Schein, 2004).

In this context of shared beliefs and knowledge, Nonaka & Takeuchi (1995) draws on the concepts of tacit and articulated knowledge to introduce four modes of knowledge conversion (see Table 2).

Tacit knowledge is non-verbalized, intuitive, and unarticulated, in contrast to articulated knowledge expressed in some written or spoken form. Moreover, tacit knowledge is clarified as either an 'issue of awareness or consciousness' or, when one is aware of the tacit dimension of its knowledge, as a communication difficulty arising from 'inadequacies of language in expressing certain forms of knowledge and explanation' (Gertler, 2003, p. 77). Either tacit or articulated forms of knowledge can be a property of an individual, group, organization, or an inter-organizational domain. Each of these modes of conversion is also an act of knowledge creation,

Table 2 Four modes of knowledge conversion (adapted from Nonaka & Takeuchi, 1995; Nonaka *et al.*, 2000)

From	*To*	
	Tacit knowledge	*Articulated knowledge*
Tacit knowledge	Socialization (creates sympathized knowledge)	Externalization (creates conceptual knowledge
Articulated knowledge	Internalization (creates operational knowledge)	Combination (creates systemic knowledge)

articulation being the 'quintessential knowledge creation process' (Nonaka & Takeuchi, 1995, p. 64).

Power, control, and trust

Johnson (1988) views organizational culture as a web of several elements: paradigm (i.e., mission, vision, and values), symbols, power structures, organizational structures, control systems, routines, rituals, and myths. These elements coexist, overlap, and even support each other. In this tightly interwoven web of cultural elements, trust is as an essential factor that contributes to strengthening the net of relationships. Lack of trust has the exact opposite effect. Thus, power structures depend on control systems; control systems are more efficient in a trusting environment, which has an impact on the power structures.

Knowledge culture

While theories of conversion of tacit and articulated knowledge were adopted more-or-less intact for use within knowledge management research, theories of a knowledge culture extend and refine the original organizational culture research. A knowledge culture characterizes an organizational culture that understands and values knowledge management. Furthermore, the initial requirement for such a culture is a top management commitment to knowledge management (Baird & Henderson, 2001), requirement which is also related to the measurement problem (see section 'Knowledge measurement'). Knowledge comes at a measurable cost to the organization, yet the problems of measuring intellectual capital complicate any monetary calculations of return-on-investment. A knowledge culture values learning and creativity, and these imply a commitment of employee time for internalizing, reflecting, and articulating knowledge. Reducing harsh bureaucratic structures and increasing informal communication will improve creativity and innovation by promoting spontaneity, experimentation, and freedom of expression (Graham & Pizzo, 1996). This culture also entails an almost total reversal of many values that underpinned the re-engineering and 'right-sizing' management culture of the early 1990s. For example, knowledge cultures value a 'fat' middle management layer for professional support and a tolerance for the functional inefficiency that a messy, chaotic creative process implies (see section 'Knowledge organizations').

A balanced environment of power, control, and trust is an essential condition for a successful knowledge-oriented culture. 'If people do not trust each other, they do not exchange knowledge and ideas' (Allee, 2003, p. 619). Trust helps build and sustain valuable networks and rewarding relationships (Allee, 2003), while lack of trust erodes knowledge leadership, creation, and transfer (Amidon & Macnamara, 2003). Additionally, in a power culture, 'knowledge is power' and people are less inclined to share it. Hence, power, control and trust are closely related not only to knowledge culture, but also to knowledge alliances, knowledge strategy, knowledge organizations, and knowledge processes (Inkpen & Dinur, 1998; Ford, 2003).

Organizational structure

Knowledge management theory borrows from theories of organizational structure, and develops several important new ideas that can improve our understanding of such structures. An example of one of these borrowed theories is the goal-seeking imperative of organizational design. The knowledge management field uses these theories to form an overarching class of concepts that refine and extend the idea of the goal-seeking imperative.

Goal-seeking organizations

The knowledge culture does not imply that an uncontrolled or 'hands-off' management style is necessary. Organizational structure theory suggests that, to be successful, knowledge management should be closely linked to organizational strategy and goals (Davenport *et al.*, 1998). Indeed, the basic idea is that knowledge strategy will guide substantial parts of the organizational philosophy about its strategy and goals (Earl, 1997). The principles of goal-seeking organizations require that the purposes of knowledge management must be expressed in clear language to guide the development and implementation of the knowledge-directed organization.

Knowledge organizations

Certain organizational structures, as 'knowledge organizations', provide part of the practical implementation of knowledge management. Although a 'chief knowledge officer' may not always be necessary (Cole-Gomolski, 1999), successful knowledge management is usually characterized by a designated individual manager in charge of the knowledge management functions (Davenport *et al.*, 1998; Earl & Scott, 1999). The action in the knowledge management process begins with the formulation and implementation of strategies for the construction, embodiment, distribution, and use of organizational knowledge. Other strategies include those for the basic management functions to monitor and

measure the knowledge assets and processes (Quintas *et al*., 1997).

In addition, the organizational context (i.e., the entire organization) may need to be revised to enable effective knowledge management. The ideal knowledge organization has been described as 'N-form', as a contradistinction to the traditional M-form that proceeds from the existing theories (Hedlund, 1999). The M-form is a hierarchical organization where communication is primarily vertical, the top management is the critical organizational layer, and the competitive scope is based on economies of scale and diversification. In contrast, in the N-form (or network) organization communication is lateral, the middle management is the critical organizational layer, and competitive scope focuses on specialization. Thus, the N-form recomposes knowledge using internal and external sources (Hedlund, 1999).

The knowledge management concept highlights two interesting aspects of knowledge organizations. First, the knowledge organization is not necessarily a knowledge-intensive organization. A knowledge-intensive firm contrasts capital- or labor-intensive firms in that knowledge is the organizational input with the greatest importance (Starbuck, 1997). Knowledge management may be critical to firms characterized as capital or labor intensive, and a knowledge organization may be essential to convert capital or labor inputs to products. Second, middle management is a critical layer in knowledge organizations for at least two reasons. One reason is that professional knowledge is usually created, transformed, and articulated in the middle management layer. Another reason is that middle management is needed to resolve the contradictions between the grand designs of top management and the limits placed on those designs by the realities of the organization's primary value chain. Middle management is central to the knowledge creation process by rationalizing top management plans and primary value-adding processes (line management) into a progressive unit. The role of middle management in the knowledge organization is to transform knowledge across organizational levels. The centricity of middle management in knowledge organizations means that these are neither top-down nor bottom-up, but rather are 'middle-up-down' organizations (Nonaka & Takeuchi, 1995, p. 127).

The importance of middle management highlights the potential conflict between the theory of the knowledge organization and the pure network organizational structures of the foundational work. Middle management is a hierarchical concept, and foundational organizational theory shows that hierarchies excel in certain fields. For example, hierarchies promote radical innovation through specialization, provide rapid infusion and diffusion of radical innovation, and provide large-scale capacities. The ideal knowledge-organizational forms may be a hybrid of network and hierarchy models: a heterarchy (Hedlund, 1999) or hypertext organization (Nonaka & Takeuchi, 1995). Nonaka and Takeuchi use the U.S. Marines as an example of such an organization: a strict hierarchy that implements its operations in task forces. The elements for each task force are mapped from the hierarchy as needed (and only when and while needed) for the task. It is notable here that knowledge management work is fielding a new rationale that renews and raises the importance of very traditional organizational theories.

More recently, new concepts focusing on inter-organizational knowledge have developed. For example, an exploratory case study at Toyota shows that the trans-organizational network is an important unit of analysis for explaining competitive advantage. Such boundary-crossing networks can be more efficient than an isolated firm at creating, reusing, and transferring knowledge, because there is greater diversity of knowledge. However, coordinating mechanisms are necessary to make such networks efficient (Dyer & Nobeoka, 2000).

Organizational behavior

Successful knowledge management focuses strongly in the realm of organizational behavior (Frappaolo, 1998). The behavioral infrastructure centers knowledge creation rather than knowledge storage or transfer. This centricity is because storage and transfer involve human interpretation, which implies a degree of creativity. Knowledge management research has imported foundational theories regarding the management of creativity, innovation, organizational learning, organizational memory, and dynamic capabilities.

Organizational creativity

Creativity theory suggests that knowledge creation is improved by non-conformity and breaking away premises, called 'thinking outside-of-the-box'. Creativity is stifled by uniformity pressures like the social needs to conform to group thinking and the fear of embarrassment. There are several known effective mechanisms. These include a reward system that promotes ideas. Free time is another mechanism, for example, permitting employees to devote a certain percentage (e.g., 3Ms 15% rule) of their time pursuing their own ideas of interest, or devoting free time for study or play. Other mechanisms include creativity training and cultural shifts that inculcate creativity values ('cultures of pride'), like valuing dissent within a group, and passion for new ideas. One mechanism is actually based on less management, more slack and more local control, leading to the relief of uniformity pressures by limiting top management control (Nemeth, 1997). This helps explain why a limited degree of chaos has been known to promote creativity and innovation, an explanation that proves very useful for improving knowledge management (Inkpen, 1996).

Innovation and diffusion

Innovation theory indicates that the innovation process is uncertain, fragile, controversial, and political, a set of conflicting, problematic attributes. Invention and creativity usually involve non-conformist thinking, which

raises a social struggle, and both the process and the result inevitably reach across clear boundaries, which raise a political struggle. Since innovation is promoted by 'cross-fertilization' of ideas, structural integration and broad job definitions within organizations can promote innovation by lowering political barriers and exposing contrary premises. Champions and coalitions will help advance new ideas, and some organizational structures lead to coalitions: team mechanisms, employee mobility, and open communication. The work in innovation transfer and diffusion research relates to the knowledge management focus on knowledge transfer and transformation. Strategic alignment and structural links between organizations (see section 'Knowledge alliances') are known to be effective, as well as the creation of active change agents and communications channels (Kanter, 1988). Table 3 enumerates other organizational features shown to characterize a 'fertile field' for innovation, and these theories have important uses in knowledge management.

Organizational learning

Research in learning organizations provides a further source for knowledge management concepts used to create knowledge organizations. The recognition that organizations (as well as people) learn has gained prominence with the increasing importance assigned to the theory of double-loop learning (Argyris & Schön, 1978). This theory explains why certain shared, tacit learned behavior remained in an organization even when the people involved are gradually changed (Weick & Gilfillan, 1971). Individual behavior is adapted as the individual learns in a single loop. Organizational behavior changes as individuals adapt to others in a double loop. Managing knowledge necessarily involves managing organizational learning. From this perspective, organizational learning is related to organizational adaptation and change, a research area with certain traditions in human adaptive systems (McElroy, 2003).

Organizational learning is also a form of knowledge creation that is closely tuned to the shared value system of people in a social setting, and is often only truly effective when there is a action orientation that motivates this learning (Argyris, 2004). Senge (1990) motivated this theory by demonstrating the value of the workforce commitment to shared organizational goals, and advanced a theory that links organizational learning, human communities, and general systems concepts. These three elements form essentials: first, a set of practices for generative conversation and coordinated action (double-loop learning), second an organizational culture that values humility, compassion, and wonder, and third a managerial capacity to understand and work within a human system (Kofman & Senge, 1995).

Table 3 Features of organizational 'fertile fields' for innovation (adapted from Kanter, 1988)

1. Inter-organizational interdependence.
2. Collocate innovators and consumers and promote their communication.
3. Favor skilled, professional, cosmopolitan workers.
4. Enable the flow of ideas out of R&D centers.
5. Create a complex or 'heterogeneous' work setting.
6. Reward, socially, and otherwise, new ideas.

Organizational memory

Organizational memory relates to the tenet that groups and organizations can store tacit knowledge. It is concerned with storing history and information, a narrower concept than knowledge. Organizational memory refers to individual recollections and shared interpretations of historical information consequent to implementing earlier decisions and brought to bear on present decisions. This information is also retained as organizational culture, routines, organizational structures, and the workplace ecology. Organizational memory is also retained in articulated form as internally or externally stored archives (Walsh & Ungson, 1997). Paradoxically, organizational memory can both enable and inhibit organizational learning. On the one hand, organizational memory retains decision programming, which enables organizational learning in the sense that information about successful and unsuccessful decision programs and their outcomes are retained. On the other hand, organizational memory can interfere with organizational learning by blinding decision-makers to aspects of decision settings that were not present in the past. Organizational memory biases decision-making toward the *status quo*, inhibiting double-loop learning. Further, defective organizational memory can lead to 'revisionist history,' in which corporate history is rewritten to make earlier judgments seem sounder. Poor organizational memory limits organizational learning because decision-makers are unable to learn from past mistakes (Demarest, 1997). Improved knowledge management extends this paradox because definitions of knowledge typically encompass such historical information. Better knowledge management can improve the accuracy and breadth of organizational memory, extending the effects noted above, and better enabling interpretation and reflection, thereby extending the paradoxical effects even further.

Knowledge creation

The field of knowledge management contributes several recent models of the knowledge creation process. A well-known example proceeds from the various collaborations of Gunnar Hedlund and Ikujiro Nonaka. Figure 1 illustrates the model of organizational knowledge creation process, adapted here from Nonaka & Takeuchi (1995, p. 84). Tacit knowledge is socialized into the organization from its customers and knowledge alliance partners. This knowledge is processed iteratively through five processes as tacit knowledge is articulated/externalized and combined to support a product or service output of the organization. In this sense, externalization

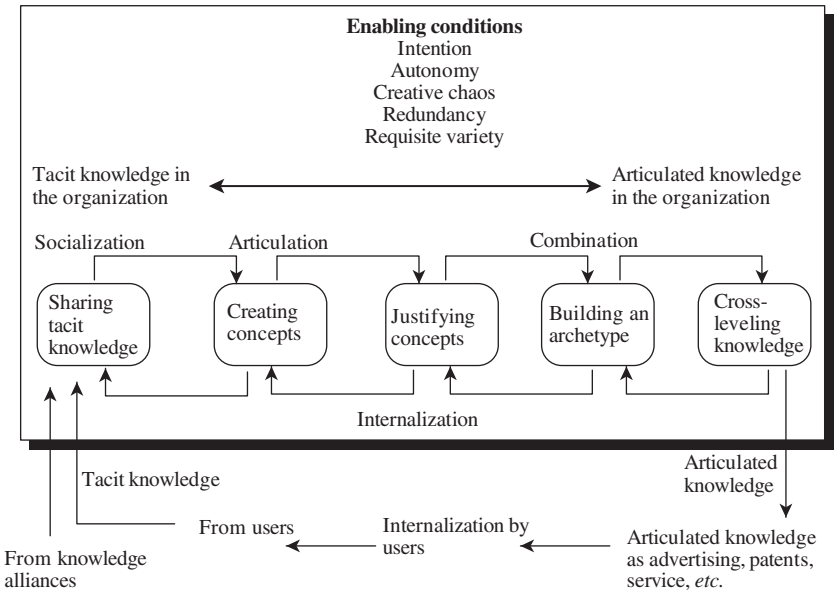

Figure 1 Organizational knowledge creation process (adapted from Nonaka & Takeuchi, 1995).

is the process by which tacit knowledge is transformed into articulated knowledge and internalization is the reverse process. Several important prerequisite conditions are notable for enabling the process. These manifest a knowledge culture by investing the individuals with a degree of autonomy, and providing a degree of redundancy in the workforce to enable reflection and creativity. Also notable is the 'creative chaos' that must be fostered to promote innovation and creativity (Inkpen, 1996).

The knowledge creation process is not a static process, but a spiraling one and dynamic interactions occur at different levels as both tacit and articulated knowledge are held by individuals, groups, organizations, and inter-organizational domains (see Figure 2). Expansion represents the interplay among the four activities (socialization, externalization, combination, and internalization). The two processes by which knowledge enters the system and exits the system are assimilation and dissemination, respectively.

The SECI model has been revised several times and new concepts such as 'ba' (Nonaka & Konno, 1998) leadership (Nonaka *et al*., 2000), and dialectical thinking (Nonaka & Toyama, 2003) have been added. Particularly interesting to our discussion is the concept of 'ba', which represents a shared space for knowledge creation. Participation in a 'ba' has created another form of knowledge creation, the shared knowledge creation, which is the fundamental property of collaborating activities such as communities of practice, knowledge networks, and strategic communities (Kodama, 2005). In this context, knowledge becomes a group resource, rather that an individual one, and supports faster learning (El Sawy *et al*., 2001). Moreover, in group settings, sense-making activities are viable processes for creating knowledge with strategic implications (Thomas *et al*., 2001; Cecez-Kecmanovic, 2004). Sense-making is defined as the social interaction among people and their environments, with high potential for collective learning (Boland Jr & Yoo, 2003).

Knowledge codification

Knowledge codification involves the explicit organizational processes of locating knowledge sets, facilitating knowledge articulation, and enabling access to this knowledge (Sanchez, 1997). The objective is to put organizational knowledge into a form that is accessible to those who need it (Davenport & Prusak, 1998). This process is not simple as organizational knowledge is a 'phenomenon in process' and needs to be extracted in its cultural and organizational context (Patriotta, 2004). Knowledge codification involves the meticulous discovery of critical tacit knowledge that the organization has created, learned, or organized. Once discovered, this knowledge must then be articulated in a form that can be absorbed by others in the organization who could use the knowledge. Further, there must be a means by which those in need of the knowledge can discover its existence as reposed, articulated knowledge.

While knowledge codification is a complex process, some guide mechanisms have been developed as aids. For example, knowledge profiles are one means by which organizational proficiency levels in various knowledge domains can be captured. Once these levels are known, domains in need of codification can be prioritized (Wiig, 1995). Mechanisms for articulating tacit knowledge for codification include narratives, embedding knowledge systems, and knowledge models. Narratives involve capturing stories that illustrate tacit knowledge. Embedding tacit knowledge into systems involves knowledge engineering for the purposes of capturing rules and relations within a computer-based expert system. There are also examples of mechanisms for cataloging articu-

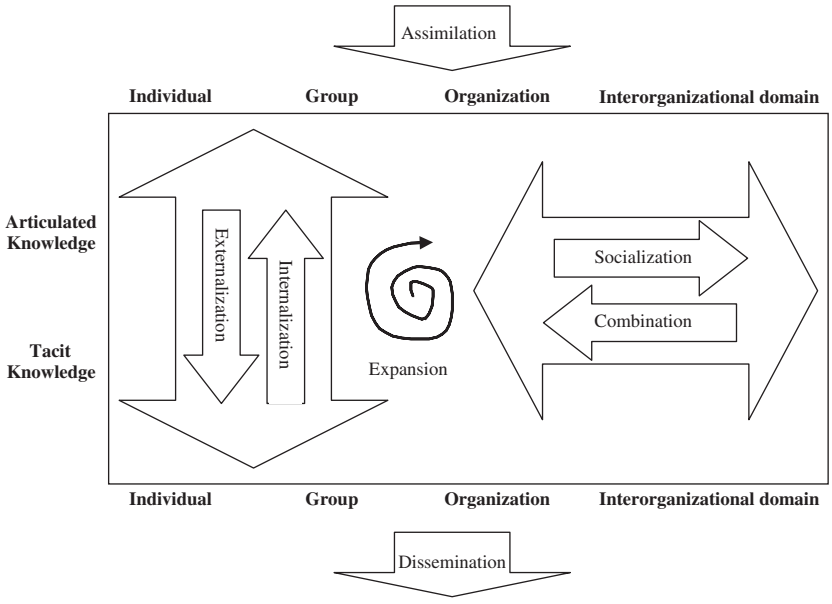

Figure 2 Knowledge categories and transformation processes (adapted from Nonaka & Konno, 1998; Nonaka *et al.*, 2000; Nonaka & Toyama, 2003).

lated knowledge for the purposes of its discovery when needed. Knowledge maps, in the fashion of cognitive maps, can be used to publish the locus and relationships of different kinds of knowledge in an organization. Knowledge models have been used to transform detailed levels of articulated knowledge into a more abstract and generalized form. These knowledge abstractions can be used by those seeking knowledge in a particular field to search for related articulated knowledge (Wiig, 1995; Davenport & Prusak, 1998).

Knowledge transfer/reuse

Knowledge transfer[4] is somewhat difficult to distinguish from learning, perhaps providing a product view that contrasts the process view characterizing individual and organizational learning. While knowledge transfer is closely related to other concepts, it takes a particular form in IS and software engineering as the concept of knowledge reuse (Markus, 2001). On the one hand, knowledge personalization is distinguished from the knowledge codification by its focus on dialogue between people instead of knowledge objects in a database. It is based on the assumption that unique expertise or knowledge cannot be codified, but can be transferred in brainstorming sessions and in one-to-one conversations (Hansen *et al.*, 1999); codification is a reuse strategy, while personalization is a development strategy.

[4]'Knowledge Transfer' is used here in a general sense and no distinction is made *vs* 'knowledge sharing' or 'knowledge dissemination', which are two other terms frequently used in the literature to express the exchange of knowledge between the source of knowledge and the recipient of knowledge.

On the other hand, knowledge reuse is theoretically linked to knowledge objects and repositories. Reuse through repositories may involve knowledge and sharing between knowledge producers, reuse through shared work practices, reuse by expertise seeking novices, and reuse by secondary knowledge miners (Markus, 2001).

Knowledge transfer is also related to the firm's absorptive capacity (or its lack of) (Alavi & Leidner, 2001). The absorptive capacity is defined as the 'ability to identify, assimilate and exploit knowledge' (Venkatraman & Tanriverdi, 2004, p. 56) and its absence can convert the knowledge to be transferred into 'sticky knowledge'. Sticky knowledge represents knowledge whose transfer is problematic and the sticky character reflects the incremental cost of the transfer (Szulanski, 1996). Stickiness is not always a negative property; used in the context of knowledge networks, it describes a set of measures to avoid natural attrition (Bush & Tiwana, 2005).

Artificial intelligence

Originally tools and technology were seen to play a second-tier role in supporting knowledge management because it is problematic to build tools that automate the cognition process. Authorities believed that it is far too easy to focus on knowledge management technologies and neglect knowledge content, culture, and motivation (Davenport, 1997b). Given the key role of human individuals in creating, storing, and transferring knowledge, it is not surprising that the tool concepts are emergent rather than fully developed. There are fields of existing work that are clearly relevant and useful. For example, knowledge management is drawn toward knowledge-base systems theory. Beyond importing these

concepts, knowledge management has moved them into broader theories: the knowledge infrastructure and knowledge architecture. Furthermore, tools from the data mining have been exported under the concept of knowledge discovery. Consequently, these three concepts (knowledge infrastructure, knowledge architecture, and knowledge discovery) have become available as ideas providing useful applications and expansions of the concepts in artificial intelligence.

A substantial portion of the research in this area might be characterized as design science (March & Smith, 1995). Theories in design science focus on the characteristics and behavior of artifacts, and tend to be prescriptive or teleological (as opposed to explanatory theories in traditional behavior science). A design theory in knowledge management will draw on foundations as 'kernel theory' in the development of design process and design product (Walls *et al*., 1992).

Knowledge-based systems

Recognition of the distinctly human quality of knowledge has grown from the experience in knowledge-based (expert) systems (KBS). Authorities on KBS never agreed that KBS technologies were capable of replacing human expert knowledge. Still, the envisioned 'support' role of KBS theory is further shifted under the view of knowledge management. No longer seen as standalone, comprehensive solutions to knowledge problems, KBS serve as building-blocks or tools: components of a diverse knowledge management infrastructure (Wiig, 1997b). The contemporary tool set for knowledge management is a hodgepodge of executive IS, group support systems, decision support systems and knowledge-base systems (Davenport, 1997a). KBS technology is not merely an explicit component in this tool set, but has also become more-or-less embedded in many of the other components, for example, holistic decision-support systems (Mirchandani & Pakath, 1999). The development of such KBS technology involves knowledge engineering as well as normal software engineering practices (Studer *et al*., 1998).

Data mining

Important among these infrastructure components has been data warehousing and online analytical processing. Together, these enable knowledge creation through the use of data mining techniques that not only include basic KBS, but fuzzy logic, case-based reasoning, genetic algorithms, neural networks, and intelligent agents (Desouza, 2002). Data mining implies a knowledge infrastructure in settings where very large stores and flows of data are available and must be made accessible and understandable for decision-making. These stores and flows can only be used for knowledge creation through the means of complex technical tools to aid in the logical and practical digesting of data into information.

Knowledge-support infrastructure

Knowledge management implies a knowledge-support infrastructure and designs for knowledge-support architecture. The overlap with information infrastructures is large, since most of the potential components extend the human ability to store and access information, thereby aiding the human process of creating and applying knowledge. Advances in knowledge systems are important because a standard, flexible knowledge structure is one characteristic of successful knowledge management (Davenport *et al*., 1998). For example, group support systems provide features like variably structured database storage, workflow programming, and rationale explication that can be used to capture aspects of organizational knowledge; intranets enable organizational access to dispersed explicit knowledge. The KBS and related artificial intelligence advances for storing rules and patterns are also important.

Table 4 highlights examples of such tools that might be used as technical components in such an infrastructure. The two elementary knowledge tasks are knowledge creation and knowledge transformation. For the purposes of this example, knowledge creation encompasses knowledge storage since storage and retrieval imply interpretation and context. Also, knowledge transformation similarly encompasses knowledge transfer. The elementary knowledge applications are drawn from Figures 1 and 2. Some tools listed in the table could fit in several, if not all of the application categories. The purpose of the list is to demonstrate that a knowledge-support infrastructure can be contrived to support all of the elemen-

Table 4 Examples of knowledge-support infrastructure components

Knowledge task	*Knowledge application*	*Tool examples*
Knowledge creation	Socialization, sharing tacit knowledge	Video conferencing, groupware
	Externalization, creating concepts	KBS, CAD, workflow, authoring tools
	Combination, building archetypes, or cross-leveling	Case-based reasoning, simulation tools, decision support tools, object modeling
	Internalization	Data mining, query tools, CBT
Knowledge transformation	Extension	KBS, electronic publishing
	Appropriation	Data mining, query tools, CBT
	Assimilation	Intelligent agents, executive IS, search engines
	Dissemination	Electronic publishing

tary knowledge tasks. The need for human interaction limits support for socialization, although telecommunications, conferencing, and groupware can help (to a limited degree) overcome time and place limitations. Tools that support human expression, like word processing, hypertext and computer-aided design dominate articulation applications, including the use of KBS to capture rule bases and workflow tools to capture tacit process policies. Tools that help people synthesize and theorize can assist knowledge combination. Tools that help people internalize explicit knowledge or to appropriate knowledge from higher levels include computer-based training, and query tools. Finally, the extension and dissemination of knowledge may be improved by publishing knowledge-bases or web-based hypermedia.

Knowledge architecture

The focus of knowledge architecture is clearly lodged in the structure of knowledge captured in systems. It is closely related to infrastructure because infrastructure is focused on the systems that capture and store structured knowledge. Two key development fields are knowledge modeling and knowledge ontologies.

Design science work in knowledge modeling regards various strategic models for organizing knowledge-based systems, referencing such kernel theories as smart objects for data and knowledge representation (Vaishnavi *et al.*, 1997). Another example is a worldwide knowledge grid that represents knowledge in a three-dimensional space comprised of knowledge category, knowledge level, and location. Knowledge management is the activity of managing globally distributed knowledge resources by locating these as a point in the three-dimensional space (Zhuge, 2002).

Ontological developments extend the earlier work in knowledge bases by drawing on the web ontologies (O'Leary, 1998b). An ontology is 'a shared and common understanding of some domain that can be communicated across people and computers' (Benjamins *et al.*, 1999, p. 691). Since most knowledge-based systems contain several knowledge bases, and these in turn rely on ontologies for clear specification of their characteristics and views, knowledge management ontologies are good candidates for creating intelligent knowledge retrieval components (Holsapple & Joshi, 2003).

Knowledge discovery

Knowledge discovery aims to extract knowledge from knowledge warehouses (e.g., data warehouses storing qualitative data; O'Leary, 1998a). Knowledge discovery techniques promise important benefits to fields such as marketing (Shaw *et al.*, 2001) or library management (Wu *et al.*, 2004). Knowledge discovery builds on the earlier work in the use of data mining techniques for intelligent data analysis and efficient querying of large databases and data warehouses. Knowledge is built from information by analyzing a series of patterns produced by a knowledge-based system. The field sometimes conflates knowledge and information, for example, defining knowledge discovery as 'the non-trivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data' (Fayyad *et al.*, 1996, p. 6).

Knowledge measurement

In addition to the use of theories for motivating and determining the knowledge management process, the problem of measuring knowledge plagues many knowledge management theories. The measurement issue is a serious problem for knowledge management creating various difficulties in objectively managing a commodity that cannot yet be quantitatively measured. This recurring theme is clearly a continuing research question and practical problem in its own right. It also relates closely to quality management, because of the tenet that requires something to be measured in order to be managed. Credible knowledge measurement is also a particularly thorny problem from the intellectual capital perspective.

Quality management

At least two theories from the field of quality management have been imported into knowledge management and adapted and extended for use there. These involve two means for indirect knowledge measurement, one using risk management measures and the other using benchmarking. The particularly difficult needs of knowledge management have drawn researchers to seek innovative qualitative measures, and these qualitative frameworks are an important concept emerging as a contribution of knowledge management.

Risk management

There are possibilities for making indirect measurements of knowledge management. For example, some failures of risk management can be linked to ineffective knowledge management (Marshall *et al.*, 1996). Measuring the *outcome* of poor management knowledge may provide indications. These outcome indications may be in the form of poor management decisions, policies, and strategies. These outcome indications are limited by proper consideration of the many other possible causal factors.

Benchmarking

A second possibility for measuring knowledge management arises from strategic benchmarking, an idea that arises as a component of knowledge alliances. This process could be used to compare organizational knowledge management structures, knowledge management practices and knowledge-based strategies with a benchmarking partner. Such benchmarking projects may reveal knowledge management best practices within benchmarking partners and offer each an opportunity to improve their own knowledge management.

Knowledge equity

Information economics might be expanded to encompass the broad measure of knowledge economics. A theory of knowledge equity could develop from an analysis of the

elements that lend value to knowledge. For example, the valuable aspects of knowledge could be divided into the capabilities of 'knowers' and the properties of the information that knowers process. Information properties include context, framing, interaction, fuzziness, dynamics, and dispersion. Context recognizes that people do not evaluate items of knowledge independently, but as part of an overall context. Framing is a particular context element that regards the way a particular problem is represented. Interaction is another context element that recognizes that people correlate individual items of information that interact with each other. Fuzziness is the tolerance with which people allow for ambiguity and the boundaries separating sets of objects. Dynamics is the temporal context that accepts that the same item of information to shift meaning over time. Dispersion varies the value of information depending on who else knows it. Capabilities of the people who possess knowledge include acquisition, memory, interpretation, and meta-knowledge. Acquisition is the capability for open-minded inquiry that constitutes skilled learning and information processing. Memory is the capability to store knowledge or distribute it through a shared memory system of multiple people. Interpretation is the capability to organize structure or contextualize information and thus achieve meaning. Meta-knowledge is the capability to 'know what you know'. The theory of knowledge equity is not fully developed, but early experience suggests that a quantitative evaluation of each of these aspects of knowledge might be aggregated to yield a quantitative measure of knowledge value (Glazer, 1998).

Qualitative knowledge measurement

The well-known quantitative, quality-management measures are seen by some problematic for measuring organizational knowledge. By drawing diversely from more qualitative measurement theory, measurement frameworks have been constructed, such as the knowledge management assessment framework (Jordan & Jones, 1997). This framework has useful application for disclosing the knowledge management status of an organization, reporting changes in this status, and comparing organizations. The framework emerges from diversity in theory and method. It helps assess an organization's (1) knowledge acquisition focus and search style, (2) the location, procedures, activities, and scope of its problem-solving approaches, (3) the breadth and processes of knowledge dissemination, (4) the identity and resource type of knowledge ownership, and (5) representation mode of knowledge storage and memory. The framework is described in Table 5.

Such frameworks are highly practicable, and enable organizations define metrics that support the knowledge management initiatives and the organization's goals (Hanley & Malafsky, 2003). For example, the Software Engineering Institute developed the People Capability Maturity Model (People CMM), whose framework is based on the Capability Maturity Model for software development (Curtis *et al*., 2002). The People CMM aims to assess the maturity level of the workforce practices, thus guiding organizations in improving their processes for managing skill-set of their workforce and developing an organizational competence.

Organizational performance measurement

In addition to using quality measures for evaluation of organizational knowledge and its management, the knowledge management field draws on accounting and productivity measures, challenging the simple, yet important premise that it is very difficult and often ineffective to manage something than cannot be measured. Research on organizational performance measurement plays an important role in making better use of existing resources and potentially improving performance (Kaplan, 1983). With respect to knowledge management, researchers have used financial performance measures to assess the quality of such practices.

Financial performance measures

Financial metrics are one of the central tools for appraising performance and management of commercial organizations. Applying these measures to knowledge is complicated by the problematic nature of directly measuring changes in knowledge (Lev, 2001).

Table 5 Knowledge management assessment framework (adapted from Jordan & Jones, 1997)

Superordinate categories	*Dimensions*	*Scale*	
Knowledge acquisition	Focus	Internal sources	External sources
	Search	Opportunistic	Deliberate and focused
Problem solving	Primary unit	Individual	Team
	Procedures	Trial and error	Heuristics
	Direction of activities	Experiential, hands-on	Abstract, representational
	Scope	Incremental improvements	Radical innovation
Dissemination	Knowledge sharing process	Informal discussions	Formal meetings or databases
	Breadth	Narrow, need-to-know	Wide publication
Ownership	Locus of emotional identity	Personal identification	Collective identification
	Resource dispersal	Specialist experts	Redundant generalists
Storage and memory	Representation	Tacit	Articulated

Assuming that markets are efficient, the value of a firm's knowledge is already incorporated in its share prices. Its ability to leverage its knowledge in competing in its markets is already incorporated in its price–earnings ratio or in its market value. A pseudo-measure for knowledge creation can be the R&D expenditures of a firm. However, this measure regards the efforts at knowledge creation rather than providing any direct measure of the changes in the value of the stock of knowledge resulting from the R&D. As a consequence, work in the knowledge management arena regards financial performance research, such as event study methodology or Tobin's Q (Brainard & Tobin, 1968), as one foundation from which to launch exploration of direct measures of knowledge management effectiveness in organizations.

Performance indices

Knowledge-based assets were initially measured using classical financial measures such as cost–benefit analysis or Tobin's Q (Lev, 2001). These approaches however present obvious drawbacks as it is difficult to estimate the costs and benefits of knowledge-based assets. For instance, Tobin's Q (which is defined as the ratio between the market value of the company and the replacement value of its assets) for knowledge assets is usually high because of an underrated replacement value (Marr & Spender, 2004). Consequently, knowledge cannot be measured with metrics developed for tangible assets without some adjustments.

Recently, Chang Lee *et al*. (2005) have shown it is possible to model and measure the quality of knowledge management. Using a model of the knowledge circulation process, the measure is composed of functions assessing performance in knowledge creation, knowledge accumulation, knowledge sharing, knowledge utilization, and knowledge internalization. The resulting knowledge management performance index provides a concise indicator of the efficiency of the organization's knowledge circulation process.

Relationships among knowledge management theories

The current taxonomy (Table 1) illustrates the knowledge management literature in what may seem a rather 'flat' manner. However, some of the examples presented in Table 1 could be assigned to more than one category as their contributions apply to more than one knowledge management theory. For instance, Nonaka & Takeuchi's work (1995) can be assigned to either 'Knowledge Creation' or 'Knowledge Organizations'. Knowledge organizations are not necessarily a prerequisite, but a knowledge-oriented organizational structure is more conducive to organizational knowledge creation (Nonaka & Takeuchi, 1995).

Such multiple-category examples create bridges among the knowledge management theories (Swanson & Ramiller, 1993), meaning that a theory uses concepts from another theory. Some of these bridges span a range of theories, thus suggesting the existence of overarching theories.

Table 6 examines such bridges based on two elements: (1) references used by the examples of knowledge management theories (see Table 1) to other knowledge management theories and (2) studies citing these examples.[5] The table was filled out in the following way: by row, we put an x for each theory referenced by each entry in the last column of Table 1; by column, we put an x for each theory that cites each example in Table 1. Hence, each x in Table 6 represents a bridge. The table should not be interpreted as 'which theory references (or is cited by) which theory' but as a mix of references and citations illustrating bridges or relationships between theories of knowledge management. For instance, the Knowledge Assets row includes not only Teece's (2000) references to other knowledge management theories but also the other examples from Table 1 that are cited by various studies on knowledge assets. The diagonal shows that all the theories of knowledge management are self-referencing as well, meaning that studies from the same research stream have built on each other to further develop the corresponding theory.

The sample of articles from which this table is built is rather small and therefore a larger number of bridges might exist. Nonetheless, the table offers a crude but reliable view of the field. Analyzing the relationships among knowledge management theories helps us gain deeper understanding about which theories have had a broader impact and about the structure of the knowledge management field in general.

We define an overarching theory as a theory that has a high number of unique bridges (i.e., 'K Assets – K Culture' and 'K Culture – K Assets' represent only one unique bridge) with other theories. Thus, knowledge transfer, knowledge creation, and knowledge strategy are clear examples of overarching theories with at least 18 bridges (out of 21). They are followed by knowledge culture, knowledge organization, knowledge assets, knowledge capability, and knowledge infrastructure with at least 12 bridges. Interestingly, knowledge management theories drawing on organizational behavior are a wellspring of ideas for most of the other theories.

Using dotted frames, the table also illustrates theories developed from the same theoretical foundation (e.g., Information Economics, Strategic Management, Organizational Culture, Organizational Behavior, etc.). We can see that theories from the same theoretical foundation tend to create clusters and build on each other. For example, work on 'Knowledge Infrastructure' may also use concepts from 'Knowledge Architecture' and 'Knowledge Discovery', and *vice versa*. Additionally, from each theoretical foundation, there is at least one (when applicable) overarching theory that has been developed: knowledge assets for information economics, knowledge strategy for strategic management, knowledge creation

[5]We used the Web of Science Citation Index to identify studies citing the examples from Table 1.

Table 6 Bridges among KM theories

reference / are cited by	These theories of KM: K Economy	K Net. & Clusters	K Assets	K Spillovers	Continuity Management	Dumbsizing	K Alliances	K Strategy	K Marketplace	K Capability	K Culture	K Organizations	K Creation	K Codification	K Transfer/Reuse	K Infrastructure	K Architecture	K Discovery	K Equity	Qualitative Frameworks	Performance Indices
These theories of KM																					
K Economy	x	x		x							x		x								
K Net. & Clusters		x		x		x	x	x		x	x		x		x						
K Assets	x		x						x			x	x			x	x		x		
K Spillovers	x			x						x	x	x	x	x	x						
Continuity Mgmt					x			x					x		x					x	
Dumbsizing	x					x					x				x						
K Alliances		x	x				x	x		x		x	x		x						
K Strategy	x	x	x		x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	
K Marketplace			x					x	x			x	x		x						
K Capability		x				x		x		x	x	x	x		x	x			x		
K Culture			x				x	x			x	x	x		x	x			x		
K Organizations	x	x	x				x	x		x	x	x	x		x	x			x		
K Creation	x		x	x			x	x		x	x	x	x	x	x	x	x			x	
K Codification											x			x	x	x	x				
K Transfer/Reuse			x	x			x	x			x	x	x	x	x	x		x	x	x	
K Infrastructure			x					x				x	x	x	x	x	x	x			
K Architecture			x								x	x	x	x	x	x	x	x			
K Discovery													x	x	x	x	x	x			
K Equity	x							x			x	x							x		
Qual. Frameworks			x					x		x	x		x		x	x			x	x	x
Performance Indices			x					x					x		x	x		x	x	x	x

and knowledge transfer for organizational behavior, and knowledge infrastructure for artificial intelligence.

In sum, Table 6 shows both a diversification of the knowledge management theories via the overarching theories and a concentration of theories via the theoretical clusters from the same theoretical foundation.

Conclusions

By applying principles of taxonometric research to the uses of theory in knowledge management research, we can distinguish different kinds of theory bases. Using criteria based on the purposes by which certain theories have been drawn into the knowledge management discourse, we see how theories are used to define the rationale for knowledge management practices, the definition of knowledge management processes, and the evaluation of the practical results achieved through knowledge management.

In developing these purposes, process definitions, and evaluation approaches, knowledge management researchers have drawn from research in information economics, strategic management, organizational culture, organizational structure, organizational behavior, artificial intelligence, quality management, and organizational performance measurement. They have applied such theories as intellectual capital (rationale), organizational learning (process definition), and risk management (evaluation). As a result, they have developed a new body of theories specific to knowledge management. Examples include knowledge alliances (rationale), knowledge transfer (process definition), and knowledge equity (evaluation).

Taxonomies represent a purposeful interpretation of reality. They provide a way of slicing the world into parts that permit further study of the similar phenomena embodied by each category in the taxonomy. As a consequence, the development of this taxonomy in knowledge management theory provides two clear avenues for future research.

First, by delineating categories of similar phenomena (the classifications of knowledge management theories and their underlying reference theories), future researchers are enabled to study the general traits of the phenomena within each category. In other words, the taxonometric study is a 'breadth' analysis. Its existence enables future researchers to engage in future 'depth' analyses. For example, by delineating knowledge man-

agement theories with a basis in information economics, future researchers can explore the similarities (the general characteristics) among the economic family of knowledge management theories. Examples of such theories include knowledge economics, knowledge networks and clusters, knowledge spillovers, and knowledge continuity management. In this way, we have outlined eight categories or families of knowledge management theories that are available for future in-depth study.

Second, by providing a taxonomy based on theoretical purpose, future researchers may recognize the opportunities for alternative taxonomies for knowledge management theory. Taxonomies based on different criteria can provide alternative ways of slicing the body of knowledge management theory into different families or categories. For example, a taxonomy based primarily on the intellectual stream (economic, psychological, sociological, engineering), rather than purpose, would likely develop different groupings or families of theories. These alternative taxonomies could lead to the discovery of other general features in the body of knowledge management theory, and provide even further ranges of future study.

While there are clear avenues for future work in such taxonomies, the taxonomy provided above enables us to draw several key conclusions. First, the field of knowledge management has definable areas of cohesion in its theoretical development. For example, the theoretical work arising from a basis in artificial intelligence (including knowledge infrastructure, knowledge architecture, and knowledge discovery) is a very cohesive body of knowledge management theory. Second, the field of knowledge management has identifiable theories that are overarching in the field. Examples of such overarching theories include knowledge strategy, knowledge creation, and knowledge transfer/reuse. These theories have been highly influential across many different families of knowledge management theory.

The implications of the presence of theoretical cohesion and overarching theories are of particular interest to a field that is associated with a management buzzword. This presence indicates a field that is developing an independent body of theory with good groundwork and internal consistency. The evidence suggests that knowledge management is now a solid, maturing field of study that is building out, not only from external theory bases but also by expanding on the basis of its own theories. The field of knowledge management is clearly not a fad as suggested by Wilson (2002).

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Appendix 1

Table 7 Journals selected

Journal	*Number of articles*	*Journal*	*Number of articles*
Academy of Management Executive	1	*International Journal of Human–Computer Studies*	2
Academy of Management Review	1	*International Journal of Information Management*	1
Accounting Organizations and Society	1	*International Journal of Technology Management*	1
ACM Computing Surveys	1	*Journal of Economic Geography*	1
AI Magazine	1	*Journal of Engineering and Technology Management*	1
American Journal of Evaluation	1	*Journal of Intellectual Capital*	1
Artificial Intelligence in Medicine	1	*Journal of Knowledge Management*	2
Aslib Proceedings	1	*Journal of Management Information Systems*	6
British Journal of Management	1	*Journal of Management Studies*	3
California Management Review	11	*Journal of Marketing*	1
Canadian Medical Association Journal	1	*Journal of Spacecraft and Rockets*	1
Chartered Accountants Journal of New Zealand	1	*Journal of Strategic Information Systems*	3
CIO	3	*Knowledge Management Research & Practice*	5
Communications of the ACM	1	*Long-Range Planning*	8
Computer	1	*Management International Review*	1
Computerworld	2	*Management Science*	2
Data & Knowledge Engineering	1	*Managerial and Decision Economics*	1
DATA BASE for Advances in IS	1	*Measuring Business Excellence*	1
Decision Support Systems	6	*Methods of Information in Medicine*	2
Educational Technology Research and Development	1	*MIS Quarterly*	5
European Management Journal	2	*Organization Science*	6
Expert Systems with Applications	8	*Quality Progress*	1
Harvard Business Review	2	*Research Policy*	1
IBM Systems Journal	2	*Scandinavian Journal of Management*	1
IEEE Intelligent Systems & Their Applications	2	*Sloan Management Review*	4
IEEE Software	1	*Strategic Management Journal*	6
IEEE Transactions on Knowledge and Data Engineering	2	*Technology Analysis & Strategic Management*	2
Information & Management	3	*Technovation*	1
Information Processing & Management	1	*Training & Development*	1
Information Research	1	*Trends in Biotechnology*	1
Information Society	1		

Appendix 2

Table 8 Journals in the final sample

Journal	*Number of articles*
Academy of Management Executive	1
Academy of Management Review	1
Aslib Proceedings	1
British Journal of Management	1
California Management Review	6
CIO	3
Communications of the ACM	1
Computer	1
Computerworld	2
Data & Knowledge Engineering	1
DATA BASE for Advances in IS	1
Decision Support Systems	3
European Management Journal	2
Expert Systems with Applications	1
Harvard Business Review	1
IBM Systems Journal	1
IEEE Intelligent Systems & Their Applications	1
IEEE Transactions on Knowledge and Data Engineering	1
Information & Management	1
Information Processing & Management	1
Information Research	1
International Journal of Human-Computer Studies	2
International Journal of Technology Management	1
Journal of Economic Geography	1
Journal of Intellectual Capital	1
Journal of Knowledge Management	2
Journal of Management Information Systems	4
Knowledge Management Research & Practice	5
Long-Range Planning	8
Management International Review	1
Measuring Business Excellence	1
Methods of Information in Medicine	1
MIS Quarterly	2
Organization Science	5
Quality Progress	1
Sloan Management Review	2
Strategic Management Journal	4
Training & Development	1

Appendix 3 – List of books (final sample)

Table 9

- Ackerman *et al.* (2003)
- Argyris (2004)
- Baird & Henderson (2001)
- Beazley *et al.* (2002)
- Bergmann (2002)
- Boisot (1998)
- Choo & Bontis (2002)
- Cooke (2002)
- Curtis *et al.* (2002)
- Davenport & Prusak (1998)
- Desouza (2002)
- Fayyad *et al.* (1996)
- Foray (2004)
- Holsapple & Joshi (2003)
- Ketchen & Bergh (2004)
- Lev (2001)
- Liebowitz (2001)
- McElroy (2003)
- Myers (1996)
- Nonaka & Takeuchi (1995)
- Pettigrew *et al.* (2002)
- Prusak (1997)
- Sanchez & Heene (1997c)
- Tordoir (1995)
- Wiig (1995)

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