

Knowledge Management: A review of the field and of OR's contribution

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Abstract

This paper examines the field of Knowledge Management (KM) and identifies the role of Operational Research (OR) in key milestones and in KM's future. With the presence of the OR Society journal *Knowledge Management Research and Practice* and with the INFORMS journal *Organization Science*, OR may be assumed to have an explicit and a leading role in KM. Unfortunately, the origins and the evidence of recent research efforts do not fully support this assumption. We argue that whilst OR has been inside many of the milestones there is no explicit recognition of its role and while OR research on KM has considerably increased in the last 5 years it still forms a rather modest explicit contribution to KM research. Nevertheless, the depth of OR's experience in decision-making models and decision support systems, soft systems with hard systems, and in risk management suggest that OR is uniquely placed to lead future KM developments. We suggest that a limiting aspect of whether OR will be seen to have a significant profile will be the extent to which developments are recognized as being informed by OR.

Key words: knowledge management, operational research; organisational learning, intellectual capital.

Introduction

Knowledge management (KM) is a term that was coined less than thirty years ago, even though it refers to a set of activities that must have been occupying the minds of humans for millennia. How to make use of what we know? How to find out what others know? How to come up with new ideas? These are just a few of the facets of what has become known as knowledge management. As will become clear, this apparent contradiction of having a new term for a very long-standing phenomenon is typical of the somewhat tangled, fuzzy picture that knowledge management presents. Therefore, in reviewing the past, present and future of knowledge management, and its relationship to operational research, it will sometimes be difficult to work in terms of precise milestones and landmarks. Rather, we will often be able to give no more than indications of changes of direction or new developments.

The fuzziness raises its head as soon as we attempt to define knowledge management. There is no common agreed definition. For the purposes of this review, we will define knowledge management (KM) as “supporting and achieving the creation, sharing, retention, refinement and use of knowledge (generally in an organizational context)”. The relationship between these activities, which may be seen as a knowledge management life-cycle, is shown in Figure 1.

<FIGURE 1 ABOUT HERE>

This definition leads naturally to a further question of definition: what is knowledge? This is a very difficult question indeed to answer: for example, Mingers (2008) lists 13 different senses of the verb “I know”. We will not attempt to define knowledge here, but instead, again for the purposes of this review, adopt the pragmatic viewpoint that if someone claims to be writing about knowledge then we accept their claim.

The structure of the paper is as follows. We begin by reviewing the history of KM, which also involves diversions into its pre-history: those disciplines that led to knowledge management, but were not called KM at the time. We go on to look at the contributions of OR and the OR community to knowledge management, including a bibliometric analysis of KM papers in OR journals. We then offer some observations about future directions for KM, especially those that we believe may be most fruitful for OR.

The history of knowledge management

It is typical of any academic discourse in the business and management field that research and scholarship follow in the wake of new business and management practices: Theory follows practice more than practice follows theory. In the case of knowledge management, the first evidence that businesses were paying attention to the need to manage knowledge came in the 1980s, but it is not until the 1990s that the first academic papers and conferences were starting to comment and theorise upon this interesting new phenomenon. The explosion of interest in KM caused some to question whether this was simply a passing fad (e.g. Quintas *et al*, 1997) or seek to explain its emergence in terms of the waxing and waning of management fashion (e.g. Scarborough and Swan, 2001). However, we argue that the term ‘KM’ has become the enduring label for a history of inter-related phenomena which represent not a passing phase, but a fundamental shift in the structure of global economic organization. This section therefore raises two key questions in turn: First, why has knowledge and the need to manage knowledge become an object of management attention? Second, what is the genealogy of knowledge management as an academic discourse? These two questions cannot always be so conveniently separated, as it is often academic publications where the observations of new business and management practices are made.

Knowledge as an object of management attention

In the US several large organizations were making explicit efforts to capitalise on their knowledge before the term ‘knowledge management’ was reputedly first coined by Karl Wiig in 1986 at a keynote address for the International Labour Organization entitled ‘Management of knowledge: Perspectives for a new opportunity’ (Beckman, 1999). According to Wiig (1997b) the earliest documented success of a corporation adopting a knowledge-focus to its management practice was Chaparral Steel, which was later written about by Leonard-Barton (1995). This is unusual for a manufacturing company, as most subsequent examples of organisations cited as milestones in the history of KM might be considered information- or knowledge-intensive industries: Both Wiig (1997b) and Boisot (1998) highlight the Digital

Equipment Corporation (DEC) as a significant milestone in the development of its XCON expert system. By the late 1980s most of the large management consulting firms had begun to integrate knowledge management into their business strategy, and to offer KM in their portfolio of consultancy offerings. In 1991 the Swedish insurance company Skandia appointed Leif Edvinsson as the first Director of Intellectual Capital, a position now institutionalised in many corporations as the Chief Knowledge Officer (CKO).

Many writers point out that knowledge and knowledge processes have always been important to organisations and their managers. Quintas (2002) quotes the economist Alfred Marshall who made the claim as early as 1890 that “knowledge is our most powerful engine of production.” The question is therefore raised, why did the *management* of knowledge only start to become such an important focus to organisations in the 1980s and 1990s?

A number of related factors have together conflated the arrival of KM as a focus of organisational attention. Most prominent among these factors is the belief that we are now in the era of the ‘knowledge economy’ in which an increasing proportion of wealth is generated by organisations which have few tangible assets, and in which ‘knowledge-intensive’ organisations (Starbuck, 1992) need to compete increasingly on their ability to configure and manage knowledge. Earliest evidence of the arrival of the knowledge economy is often attributed to Machlup (1962) who conducted an extensive study of structural changes in the post-war US economy and examined the rise in ‘knowledge production.’ At a similar time Drucker (1969) was beginning to popularise the notion of a changing society and the birth of a new type of organisation populated by ‘knowledge workers.’ For contemporary knowledge management writers, the seminal work is Bell’s forecasting of the end of the industrial era and the arrival of the ‘post-industrial’ society in which knowledge and information play a qualitatively different and more important role (Bell, 1974).

Another prominent and closely-related factor is the rise of the so-called ‘information society’ in which the convergence of information and communication technologies (ICT) is transforming the means of production and facilitating globalisation. With the launch in 1969 of ARPANET, widely seen as the precursor to the World Wide Web, it is no coincidence that a new ‘techno-economic paradigm’ based on ICT (Freeman and Perez, 1988) is inextricably linked with conceptions of a post-industrial society. For Castells (1996, p.17) ‘informationalism’ is the new mode of production, where productivity lies in the “technology of knowledge generation, information processing and symbolic communication.” Thus technology has facilitated the emergence of new forms of work and organisation in global supply chains and networked multi-national corporations (Newell et al., 2002). For modern companies the evolution of technology in one sense has facilitated the potential to configure knowledge in novel ways, and in another sense has precipitated the imperative to manage knowledge more effectively: For Quintas (Quintas, 2002) the need to innovate more quickly as the economy gathers pace, and the importance of sharing knowledge across organisational boundaries, are imperatives of knowledge management in a global network society. As well as the information and communication potential of new technology, advances in knowledge-based systems and artificial intelligence have also enabled businesses to model and support organisational knowledge processes, for example in groupware

and collaborative work, decision-support systems and advanced search engines (Shadbolt *et al.*, 1999).

KM as an academic discourse

Sveiby and Lloyd's book on managing know-how (Sveiby *et al.*, 1987) is said to be the first published academic work to apply the term 'management' to 'knowledge.' However it was not until the late 1990s that Knowledge Management as an academic discourse seriously gathered momentum. This is graphically illustrated by Swan (1999), where an analysis of references to 'Knowledge Management' in a leading index of management-related journals shows more made in the first six months of 1998 than cumulatively in the previous five years. This is not to say that discourses around the themes of knowledge discussed in the previous section did not exist before this point. As we shall see in this section, the KM discourse represents a confluence of several academic disciplines – incorporating organisational behaviour, human resource management, computer science, information management, accountancy, and more – which collectively have converged on this predominantly practitioner-led phenomenon of knowledge as a focus for management attention. In this section we shall review the key academic strands which pre-configured the KM discourse. These are organisational learning, business process reengineering, expert systems/ artificial intelligence, and latterly, the resource-based (later the knowledge-based) view of the firm, which was the field within which the notion that knowledge can be managed firmly took hold. We shall then go on to see how the KM discourse diverged, leading to a so-called 2nd generation of KM.

Organisational learning

Before the conflation of the KM phenomenon, the importance of knowledge in organisations was already receiving considerable attention in the literature on learning in organisations. For example, Schön (1995) describes organisations as “repositories of cumulatively built up knowledge” and draws attention to managerial learning in an organisational context. Taking their lead from metaphors of organisations as ‘brains’ (Morgan, 1986), some have been developing the idea that organisations themselves can learn (e.g. (Senge, 1990)). Although Senge's ‘fifth discipline’ is a hard-systems approach, the other four disciplines – namely personal mastery, mental models, shared vision and team learning – essentially render this a soft systems approach (Panagiotidis *et al.*, 2001).

Although in the past, research in learning was dominated by a cognitive and mental view of learning processes, more recently sociologists and psychologists have turned their attention to the social and cultural conditions in which learning occurs, of which the organisational context is a significant realm. Organisations are networks of social relations and systems of meaning through which knowledge in the workplace is learned (Wenger, 1998). The literature on situated learning (Lave *et al.*, 1991) and Mode 2 knowledge production (Gibbons *et al.*, 1994) argues that learning in the workplace takes place more in the context of practice, than upon the receipt of abstracted and decontextualised information. Similarly Brown and Duguid (1991) observe that the work people actually do is different from the ‘canonical practices’ enshrined in company manuals and job descriptions. For Blackler (1995) practice-based theories of knowing are more useful than the objectification of ‘knowledge’ as a focus of management activity, “to avoid treating individuals as if they can be

understood in isolation from their contexts, and the contexts as if they exist in isolation from individuals” (Blackler et al., 2000). The concept of ‘communities of practice’ stems from research into situated learning in the organisation (Brown *et al.*, 1989; Lave *et al.*, 1991).

Business process reengineering

The movement that became known as business process reengineering (BPR) came into being in a relatively short space of time at the beginning of the 1990s. At that time, many managers seemed to feel a sense of dissatisfaction: businesses were facing ever-increasing competitive pressures, Western managers in particular worried that they were losing out to other countries (such as the Asian Tiger economies), and the “old ways” no longer seem to be effective. As a result, it seemed that drastic action was called for.

Two papers appeared in quick succession in top American business journals (Davenport *et al.*, 1990; Hammer, 1990), describing some “drastic actions” that organisations (mainly American) had taken. Contrary to what was widely perceived at the time, neither claimed to have invented the concept of BPR. Rather, they were trying to produce frameworks to describe and generalise what some companies had already been doing. There were four common elements in these actions:

- Radical change (as in the title of Hammer’s paper “Don’t automate, obliterate!”)
- Emphasis on process
- Exploiting information technology (IT) to the full
- “Going back to the drawing board”

This attitude that nothing was taken for granted made an immediate impression, and each of the two “schools” then produced a book (Davenport, 1993; Hammer *et al.*, 1993). Hammer and Champy’s was a runaway best-seller, thus creating a great deal of popular interest and winning the “name” battle for the activity to be called business process reengineering.

Business process reengineering turned into a classic business “fad”, with a strong backlash against it. Davenport’s own analysis of what went wrong sums it up very well (Davenport, 1995). He describes “reengineering fever” as leading first to too much emphasis on technology at the expense of people, and then to too much emphasis on cost reduction (to pay for the technology and the consultants’ fees). As Davenport puts it: “If you call massive layoffs re-engineering, people will not want to ‘be re-engineered’”.

However, as the BPR movement collapsed, so knowledge management arose, and there were and are clear links between the two. These include the realisation of the importance of knowledge for organisations, an emphasis on process thinking, the need to balance people, process and technology views, and not least the continuing presence of Tom Davenport. Two ideas in particular, the use of IT to change how work is done, not just for greater efficiency, and stepping back to think with a “blank sheet of paper”, have great resonance with OR approaches.

Expert systems/ Artificial intelligence/ knowledge engineering

Another of the precursors of knowledge management, although curiously it is seldom acknowledged as such, comes from work within the field of artificial intelligence on expert/knowledge-based systems, and especially the work on knowledge engineering, i.e. the development of knowledge-based systems. The connection to knowledge management is evident in the word knowledge, but goes much deeper. The study of artificial intelligence “the science of making machines do things that would require intelligence if done by men (*sic*)” (Minsky, 1968) dates back to the 1950s, and work on expert systems – systems displaying a high level of expertise in a narrow domain – began in the 1960s. The phrase knowledge-based systems later came to be preferred by many to the more pretentious expert systems, but both phrases are still in common use. Seen through a KM lens, expert/knowledge-based systems represent the first sustained attempt to codify knowledge using information technology. Thirty years of experience in developing them has also given rise to a great deal of understanding of the processes of trying to codify knowledge, which in KBS terms would be called processes of knowledge acquisition.

Indeed, Karl Wiig was working on expert systems at the time he coined the term knowledge management, and the short final section of his book on expert systems (Wiig, 1990) is one of the earliest publications of any kind on knowledge management. Similarly, the bread-making example discussed by Nonaka and Takeuchi (1995) would be seen as a typical AI example by those in that area. This involved the attempts by the Japanese company Matsushita to develop a home bread-making machine. Only when one of the software engineers effectively apprenticed herself to a master baker to learn how it was done was the task successfully accomplished. AI specialists would see this as an example of the role of the knowledge engineer.

The two main avenues used in codification in expert/knowledge-based systems are knowledge elicitation from human experts, and machine learning. The latter has led to the field of data mining, while the legacy of the former in the shape of rule-based systems/routines is now commonplace, as anyone who has used software with a “wizard” will testify. However, the implications of the knowledge elicitation work on tacit, implicit and explicit knowledge seem to have been largely overlooked.

Resource-based view of the firm

The notion that knowledge can and should be managed emerges most obviously among those who advocate a resource-based view of the firm, which was first developed by Grant (1991). Grant subsequently discussed the centrality of knowledge to the resource-based theory (Grant, 1996; Grant, 1997). Although resource-based theory does not necessarily render knowledge a direct object of management, according to Spender (1996), those who take this view of the firm tend to seek ways in which knowledge is a “transferable, objective commodity” and subject to codification. This treatment of knowledge is also evident in the discourse around ‘intellectual capital’ (Edvinsson *et al.*, 1996; Wiig, 1997a), with managers seeking to measure and control the intellectual value of their organisations. Although Nonaka was not necessarily an advocate of the resource-based view, his influential theory of organisational knowledge creation (Nonaka, 1994; Nonaka *et al.*, 1995) was

instrumental in popularising the notion that knowledge needs to be made explicit in order to be managed, and has become a central tenet among those who advocate the resource-based view.

From 1st generation to 2nd generation KM

According to Roos and Von Krogh (1996), Sveiby (1996), Quintas et al (1997), Alvesson and Karreman (2001) and Scarbrough and Swan (2001), the early KM discourse therefore evolved around two perspectives on knowledge. One perspective treats knowledge as a reifiable object, capable of being packaged up, owned and passed around, characterised as the ‘cognitive’ (Swan et al., 1999) or ‘cognitivist’ (Von Krogh, 1998) perspective. Another perspective treats knowledge - or more significantly ‘knowing’ (Blackler, 1995) - as a human process which occurs between people in social networks, characterised by Swan et al. (1999) as the ‘community’ perspective. A similar distinction is made by Cook and Brown (1999) - although not in the context of knowledge management - between an ‘epistemology of possession’ where “what is known is typically treated as something people possess,” and an ‘epistemology of practice’ which takes ‘knowing’ as its focus.

According to Hansen et al (1999), these approaches become manifest in two broad strategies for knowledge management: ‘Codification’, where the emphasis is on the relationship between people and documents - the advice for a company following a codification strategy is to “develop an electronic document system that codifies, stores, disseminates and allows re-use of knowledge.” The alternative strategy is ‘personalization’, where the emphasis is on the relationship between people - the advice here is to “develop networks for linking people so that tacit knowledge can be shared.”

Thus in the early days, KM practice was dominated by an emphasis on codifiable information and investment in technology for knowledge capture and storage. Recognising the limitations of an information-centric approach which characterised the so-called ‘first generation’ of KM initiatives, the discourse shifted to how people know and learn in the workplace, with a greater practical emphasis on how to encourage people to generate and share knowledge in organisational and social networks. Information and communication technology still plays a role, but in the second generation of KM practice the emphasis has now moved to the use of so-called ‘web 2.0’ tools to support an organic and less managerial approach to social participation in KM.

KM in practice

A practitioner perspective on the development of KM is provided by the results of the MAKE awards (Most Admired Knowledge Enterprises). These have been decided as part of a research study carried out annually by Teleos, a research company specialising in KM and intellectual capital, in association with the KNOW network, beginning in 1998. They are based on a survey of practitioners, covering the Fortune 500 companies and Chief Knowledge Officers of other organisations regarded as being “expert” practitioners. Respondents are asked to nominate companies and then rate them on eight attributes:

- creating an enterprise knowledge-driven culture
- developing knowledge workers through senior management leadership

- developing and delivering knowledge-based products/solutions
- maximizing enterprise intellectual capital
- creating an environment for collaborative knowledge sharing
- creating a learning organisation
- delivering value based on customer knowledge
- transforming enterprise knowledge into shareholder/stakeholder value

Lists are then compiled of those nominated, “finalists” (typically the top 50), the Top 20 and the overall winners, together with the leaders in particular business sectors and geographical regions. Table 1 shows the Top 20 in 1998 and in 2007.

<TABLE 1 ABOUT HERE>

The 1998 list serves as an *aide memoire* of companies that were seen as pioneers in knowledge management and/or intellectual capital: all of those in the Top 20 were either pioneer users of KM, or pioneers in providing KM software and systems for others. It is strongly biased towards companies with headquarters in the USA (16 out of 20), and the only other region represented is Europe.

By contrast, the 2007 list shows more of an emphasis on companies whose business is providing information/knowledge (the BBC, Google, Wikipedia and perhaps Microsoft) and has much more of a global spread, including four companies based in Asia and four regarded as having “global management structures”. For more detail on the 2007 study, see (Chase, 2007). Three companies (Accenture/Andersen Consulting, Ernst & Young, and Microsoft) have won awards in all ten years so far.

Although a “snapshot” comparison, the above differences are indicative of the trends in the more detailed study. There has also been an increase in the diversity of the business sectors of the nominated companies. In 1998, almost all the nominated companies came from just six sectors: chemicals, computers, electronics and electrical equipment, oil and gas, pharmaceuticals and professional services, whereas in 2007 some 20 sectors are represented. The most crucial factors in winning the awards for the Top 20 companies in 2007 were success in maximizing enterprise intellectual capital and transforming enterprise knowledge into shareholder/stakeholder value.

These trends can be taken as representative of the state of KM in practice more generally in larger organisations. The nature of the study means that SMEs will not appear in the MAKE awards lists, and indeed there is evidence that the KM needs of SMEs are substantially different from those of larger organisations (Chen *et al.*, 2006; Nunes *et al.*, 2006; Sparrow, 2005).

KM and the OR community

Where is OR and Management Science (MS) in all of this? As with some other fields of endeavour, there are many OR influences and connections throughout the development of KM, if one knows where to look for them, but conversely OR is not the first area that leaps into the minds of non-OR people when thinking about the disciplines that have been involved in the rise of KM.

Many OR methodologies support the managing of information and knowledge, but the body of OR that most closely aligns with the view of KM as a social process is problem structuring methods (PSMs). PSMs aim to help individuals and/or groups of stakeholders to understand highly complex situations that are characterized by multiple stakeholders with valid but competing views of issue; the need for discussion and negotiation of what is the purpose of addressing issue; personal learning about the legitimacy of alternative views to support making progress; building further insights using modelling techniques to structure the complexity of alternative interpretations (Pidd, 2003).

Using OR modelling to analyse available views (dare we say 'knowledge?'), PSM users may come to realize more about the systemic elements of the problem such that agree-able plans for addressing the situation can be developed, and later implemented. The authoritative volume edited by Rosenhead (1989) and updated by Rosenhead and Mingers (2001) includes the 'big three' PSMs of Soft Systems Methodology (Checkland and Scholes, 1999), Strategic Options Development and Analysis/Journey Making (Eden and Ackermann, 1998) and Strategic Choice (Friend and Hickling, 2005). Other less well-known PSMs include Visioning Choices (O'Brien and Meadows, 2007) and General Morphological Analysis (Ritchey, 2006).

When exploring PSMs and KM, Montibeller *et al* (2006) identify three aspects of PSMs: modelling support, using formal modelling techniques that underpin the PSM; facilitator support, someone to lead those involved through the use of the PSM; a methodology of facilitation, to ensure the group analyses the issues rigorously and in an appropriate theoretical manner. A central theme of the modelling support is often to produce explicit representations of how individuals/groups view a situation. The process, and the representations they create, helps those involved to: *share knowledge* through recording their views and making those available for others to absorb; *organize knowledge* by structuring the views into comprehensible representations; *acquire knowledge* from what others have shared; *create knowledge* by synthesizing competing views; *use knowledge* by explicitly relating the resulting PSM outcome to the representation. Thus, this process articulates (makes explicit) some of the knowledge that is believed to be relevant and records it as a group memory. The facilitator and methodology aspects also support the indirect sharing of knowledge between stakeholders for example, through facilitation techniques and the use of paper/computer-supported knowledge capturing (Montibeller *et al*, 2006).

The apparently strong affinity between PSMs and KM does feed through to KM research, especially by those in the OR KM community (Sutton, 2001; Coakes *et al*, 2002; Edwards *et al*, 2005; Shaw and Edwards, 2005). However, beyond the OR community PSMs appear to have had little influence on KM as a field.

OR's explicit impact may be best seen through the INFORMS journal, *Organization Science*, which precipitated the knowledge management discourse with Nonaka's seminal paper in which he proposes his 'dynamic theory of organizational knowledge creation' (Nonaka, 1994). Davenport started out as an industrial engineer, which most

OR people in Europe at least would classify as coming within the boundaries of OR/MS.

OR/MS people have made key contributions to KM or its antecedents. These include Herbert Simon's involvement in the development of artificial intelligence (Simon, 1969), George Huber's work on organisational learning (Huber, 1991), and the involvement of many OR people in the socio-technical systems movement.

One particular area where OR/MS people have been active is in the production of encyclopaedias and journals. Clyde Holsapple edited the *Handbook on KM* (Holsapple, 2003), which is arguably KM's first encyclopaedia. Elayne Coakes and Steve Clarke edited the *Encyclopedia of Communities of Practice in Information and Knowledge Management* (Coakes *et al.*, 2006). Meanwhile in 2003 John Edwards became the founding editor of the OR Society's dedicated KM journal, *Knowledge Management Research & Practice (KMRP)*.

In terms of a timeline, OR interest in KM appeared to take off at the end of the 1990s. Table 2 shows some of the "firsts" in KM related to OR. These include the earliest conference streams and special issues in OR and KM, as well as the publications mentioned above.

<INSERT TABLE 2 ABOUT HERE>

In the next section we look at how the general OR community has contributed to KM development, including carrying out a bibliometric analysis.

KM in the OR literature

Preparing the articles set for analysis

The searches carried out were based on Thomson ISI's Web of Knowledge, since it includes all the major OR/MS journals. A simple search on Web of Knowledge using the phrase "Knowledge Management" as topic criterion returned 6681 hits. This was then refined by choosing articles appearing in OR/MS journals, which reduced the total to 62 articles. We aimed to use a definition of "OR contribution to KM" that was sufficiently tight to satisfy those outside the field. This was: (1) the journal includes OR or MS in its title; or (2) the journal is published by an OR group or society.

Our original search had two limitations. Firstly, it missed several articles that we knew to be there, because KM articles do not always use "knowledge management" as a key word or topic term. A "knowledge *process*" search was carried using the following knowledge processes: creation, acquisition, sharing, transfer, use, refinement, codification, retention, and storage. After narrowing down the results to OR/MS journals 134 results were obtained, interestingly when comparing the two sets of results only 13 articles appeared in both searches. This lack of overlap suggests one reason for the lack of awareness of other KM research that has often been criticised: for example, Nonaka sees his research as on knowledge creation, not KM.

The second limitation of this approach is that the Web of Knowledge category of OR/MS journals does not include all OR journals about knowledge management.

Organization Science, which is an INFORMS journal and carries a considerable amount of KM research, is listed in a different category, while Web of Knowledge does not yet list any specialised knowledge management journals at all, among them *KMRP*. We therefore added a separate search to ensure that all KM articles from *Organization Science* were included, using the same two searches as above. “Knowledge Management” as a search string returned 13 results, and the list of knowledge processes returned 28 results. In accordance with the previous results, only 3 results appeared in both sets. Finally, all the articles from *KMRP* (101 in total, from 2003 up to 2007) were included in the dataset. Thus a total of 322 articles were compiled. Finally, for comparability, the time frame for articles was established as between 1990 and 2007, reducing the number of articles to 292.

<FIGURE 2 ABOUT HERE>

Figure 2 represents the resulting articles in the dataset, presented on a time line. The first thing to notice is the difference before and after 2003, which seems less surprising bearing in mind that *KMRP* was first published in July 2003. However, the number of articles in *KMRP* published in 2003 was only 11, which does not fully explain the jump from 16 (in 2002) to 48 (in 2003). The other reason that helps explain this variation is special issues: one of *Management Science* and two in the same year from *JORS*. To sum up, the launch of *KMRP* along with three special issues expresses the strong attention paid to KM in 2003 within the OR community, which explains the sudden rise in KM articles in OR journals.

KM articles and their KM focus.

In this section we turn our focus to the different KM perspectives that are covered in this article dataset. This is done by using the categorisation of KM perspectives from the editorial paper in the first issue of *KMRP* (Edwards et al., 2003): business strategy, competitive advantage, innovation culture, leadership, organisational learning, intellectual capital, practices of KM, KM processes, social capital and networking (communities of practice), technology, and theories about knowledge. Moreover, two categories were added: performance and decision making. The articles are analysed in two groups: one has KM related articles from OR journals, while the latter represents articles from *KMRP*, as an OR sub-community.

<FIGURE 3 ABOUT HERE>

The results for OR journals in general are shown in Figure 3. Knowledge Management processes have topped the chart, indicating an implicit agreement on the significance of *processes*. At this stage, it is arguably not justified to claim that KM processes are the most researched category because OR articles may come from different perspectives. Thus, OR articles might have a slightly different opinion on what KM means. For instance, Basu (1998), in possibly the first paper with the keyword “knowledge management” published in an OR journal, examined OR in Knowledge Management. Firstly, he describes how what he calls KM evolved from three computer science research streams, namely AI, database systems, and distributed computing. This explains why he used the terms knowledge-based systems and Knowledge Management interchangeably. Then, he continues to explain KM processes from that perspective, including knowledge capture and processing. So, if

Basu's view is taken as more generally valid at the time, the processes that received top hits in Figure 3 might be explained by the fact that OR research was focusing on this area as it was the only known topic related to KM for OR: this goes with the fact that nearly all of the early-mid 1990s articles had focused one or more of the three top categories (processes, technology, and decision making).

Having explained the apparent OR focus in this period, it is easier to understand the logic for rating technology and decision making, second and third respectively. Such a position has implied that researchers were focusing on information and communication technologies that enabled organisations to make knowledge informed decisions, placing more hits for both categories. However, this attitude started to change at the turn of the century as more research started targeting other categories such as culture, leadership, and organisational learning placing it in fourth place with business strategy, competitive advantage, and innovation in fifth place.

<FIGURE 4 ABOUT HERE>

Figure 4 shows the knowledge management community's cumulative view on KM research categories, as represented by *KMRP*. Interestingly, they do share the same number one focus with the general OR area, KM processes. However, are the reasons behind this focus similar? This question has prompted us to do a second level of analysis into the KM processes being researched in both communities (*KMRP* and the general OR) which will be explained in the following section.

The similarities between the communities' two foci end at this point, as more emphasis was placed on cultural, leadership, and organisation learning. This highlights the contextual nature of knowledge (Coakes, 2007; Jyrämä *et al.*, 2007; Klein *et al.*, 2007; Ledebur, 2007; Riss *et al.*, 2007), people's ability to grasp (learn) that knowledge (Chapman *et al.*, 2007; Jashapara *et al.*, 2006; Rosendaal, 2006). A closely related category is social capital and networking that fared much better within KM than in OR. The value of creating communities for KM emerges (Fahey *et al.*, 2007; Hasan *et al.*, 2007; Usoro *et al.*, 2007) as a crucial player in today's KM view. Interestingly, technological dimensions were not neglected by the *KMRP* community; this supports the notion that technology has a major role in delivering KM relying on the supportive capabilities provided by technology systems (Arnaert *et al.*, 2005; Evangelou *et al.*, 2005; Ruikar *et al.*, 2007; Schwartz, 2007). Performance has received attention on a different approach using auditing and assessment methodologies (Alstete, 2007; Dattero *et al.*, 2007), rather different from what previous OR performance measures would look like. Thus it is clear that there is a difference in emphasis in the subject matter of KM papers appearing in *KMRP* and in other journals within the OR community.

KM processes:

Figures 5(a) and 5(b) depict the Knowledge Management processes studied in the two communities. While *KMRP* scored high on sharing and creation, the wider OR community scored high on knowledge transfer and acquisition. This is consistent with previous noticeable trends as *KMRP* has placed more attention on culture, leadership, and organisational learning, along with social capital and networking, both of which can be seen as vehicles for knowledge sharing and creation using the road of

technology (Ciabuschi, 2005; Cress *et al.*, 2006; Usoro *et al.*, 2007). While OR has followed up on their assumptions about knowledge being an object that can be acquired and transferred (Chua *et al.*, 2008; Setiono *et al.*, 2006).

In summary, despite the recent history of KM showing a stronger presence of OR related activity, OR contribution to KM is still relatively modest with only 322 articles from the 6681 papers initially found. Post-2003 KM OR publications are averaging at 38 publications per year with a very healthy increasing trend. We believe that this trend can continue for there are many future directions which OR is uniquely placed to capitalise upon e.g. risk management; personal KM including methods for individual decision making; reinterpreting KM in several ways including its interaction with decision support, complexity and community OR. We now discuss these areas for future research.

The Future

In this section we identify what we believe are the most potentially fruitful areas for “KM with an OR flavour” in the future.

Risk management

The area of risk management is attracting increased attention across many management disciplines. The risks may be financial, safety, security, project, technological or economic, to name just a few types. Since knowledge has a crucial part to play in the avoidance or mitigation of risk, the potential benefits of a closer alignment between knowledge management and risk management are clear. However, academic (or even practical) disciplines can be just as guilty of a “silo mentality” as are departments in a business, and the demarcations around some topics within risk management are very sharp indeed. Financial risk management, medical risk management and nuclear risk management have all traditionally tended to work very much within their own self-referential world.

However, the context of this decision-making has changed in the 21st century, because of the influence of public opinion. For example, the public reaction to various financial scandals, starting with that of Enron, has led to changes in the way that financial management is carried out and reported, and this greater openness also means that there is a greater opportunity for combating disciplinary insularity. Similarly, attitudes to security were changed forever by the events of 9/11.

What is evident in most of the areas is that it is not enough to address risk management solely from a “scientific” or technological viewpoint, for example based on financial theories of credit risk. It is also necessary to include social perceptions of risk as well. This is where OR, with its ability to combine hard and soft approaches, can continue to make a contribution, e.g. in project risk (Ackermann *et al.*, 1997). Indeed, financial risk management ought to be particularly fertile ground, since the contributions of OR in models for credit scoring have already been considerable: see for example Thomas *et al* (2002).

Not that this will be easy: recognising the need for broader approaches is one thing, but actually implementing them to everyone’s satisfaction is quite another. The

contribution of KM to financial risk management was being advocated as early as 1996 by one of the pioneers of KM, Larry Prusak (Marshall et al., 1996), but progress has been very slow since then (Rodriguez *et al.*, 2007).

Personal KM

Most theorising about knowledge management (KM) has been at the organisation level. However the first decade of KM practice has shown that social, cultural and political factors usually inhibit organisations' efforts to 'manage' the knowledge of their members. This evidence may have borne out many critics' claims that the notion of knowledge management by organisations and their managers is an oxymoron, and that the only sensible way to conceive of knowledge management is at the individual level. Thus the attention of academics and practitioners is turning to Personal Knowledge Management (PKM), that is, how do we, as individuals, manage our personal knowledge, and what tools, techniques and models can be developed to enhance our personal effectiveness and improve our lives as 'knowledge workers' in today's information society.

OR people are well-equipped to contribute here, because of OR's long history of studying how individuals make decisions and providing them with modelling techniques for this, for example cognitive mapping. Problem structuring methods of all kinds are needed for PKM, especially those that explicitly aim to represent a particular viewpoint about a human activity system. Analytic methods to help work more effectively, rather than just more efficiently, are also vital, as are techniques to deal with information overload. Although OR, like KM, has often been seen as solely having a "corporate" emphasis, there is a long history of approaches that can be used by and for individuals: see for example Rosenhead (1989).

Multiple views of KM

We are entering the third generation of KM – there has been too much of a backlash against the over-technologised first generation of KM, resulting in too much attention being paid to the very soft end of the subject. There is scope for more analysis and decision support in KM, and this is of special relevance to OR. Social network analysis, a topic with a history as long as that of OR itself, seems to have been neglected by the OR community, as are many of the continuing developments in intellectual capital, or indeed measurements/evaluation of all kinds related to KM. Simulation offers possibilities but it is not the discrete event simulation that OR people will be most familiar with: see for example the work on computational modelling of organisations by Nissen and others (Nissen et al., 2008). Complexity theory, which has close associations with soft OR and systems, is moving into the mainstream, in part because of developments in KM (Snowden *et al.*, 2007). However, there is a rather uneasy relationship between complexity and soft systems: see for example Checkland's comments about the inaccuracy of the description of SSM given by some advocates of complexity theory (Checkland *et al.*, 2006).

In parallel with this is taking the principles of KM into alternative spheres – taking KM out of the corporate/business sphere and into other contexts, where the priority is not profit, but a more social benefit e.g. preserving heritage for future generations,

farming knowledge sharing in third world, health provision in India, social responsibility to preserve the history of the nation which is written into some constitutions. These can benefit from KM, but where is KM here – with a few exceptions such as Hasan (2008) and work on large government institutions, everyone is looking at for-profits. The notion of community KM - cKM - where social communities preserve knowledge of their own communities through various means – is becoming more typical with social networking, but there are many initiatives worldwide e.g. books on local communities and villages which have utility for generations, where KM has much to contribute. The tradition of “community OR” can offer KM considerable lessons here.

Conclusion

This paper has explored the origins of KM as an academic and practitioner discipline, arguing that the role of OR has been discrete but spread across numerous aspects of KM. While OR may have underpinned a vast number of significant milestones, infrequently have they been explicitly labelled OR, suggesting that the slogan ‘OR Inside’ is the case here (i.e. OR informs the inside workings of KM but is not readily visible). For example: the algorithms which underpin many knowledge based systems and search engines ensure OR Inside; many of the OR community have been visible through organising special issues, journals and books whether or not OR has taken a prominent position; many of the key figures have been shown to have emerged from an OR background. Consequently, despite a breadth and depth of significant involvement, the modest visibility of OR means its place in the history of KM could be forgotten.

Nevertheless, the future is bright. With an increasing number of journal articles on OR and KM being published we can clearly see space for the role of OR. We believe that there are three opportunities for OR to use its extensive past to significantly develop KM. The first is on risk management where OR has a strong tradition of modelling and can productively contribute analytical methods and conceptual frameworks, merging hard and soft approaches. On personal KM, the decision making methods at the heart of OR might usefully be translated to individuals. Lastly, OR’s strengths in decision support, social network analysis, complexity and community OR all may be future research trajectories. In each of these cases, OR would itself benefit from further development by being applied in this alternative domain.

More generally, OR can learn (again) the lesson which seems is often overlooked – that having OR Inside may be satisfying, but does not improve the overall profile of OR. While we agree with the sentiment that having OR Inside is important, we suggest that having OR Outside is equally so, not least to improve the visibility of the discipline and ultimately ensure OR’s standing in academia and practice.

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Figure and Table captions

Figure 1: Knowledge management life-cycle

Figure 2: Number of published KM articles in OR journals 1990-2007

Figure 3: Categorisation of KM articles in OR journals

Figure 4: categorisation of articles in *KMRP*

Figure 5 (a) and (b): Further breakdown of KM process articles

Table 1: Top 20 Most Admired Knowledge Enterprises (in alphabetical order) 1998 and 2007

Table 2: KM “firsts” related to OR

Figure 1

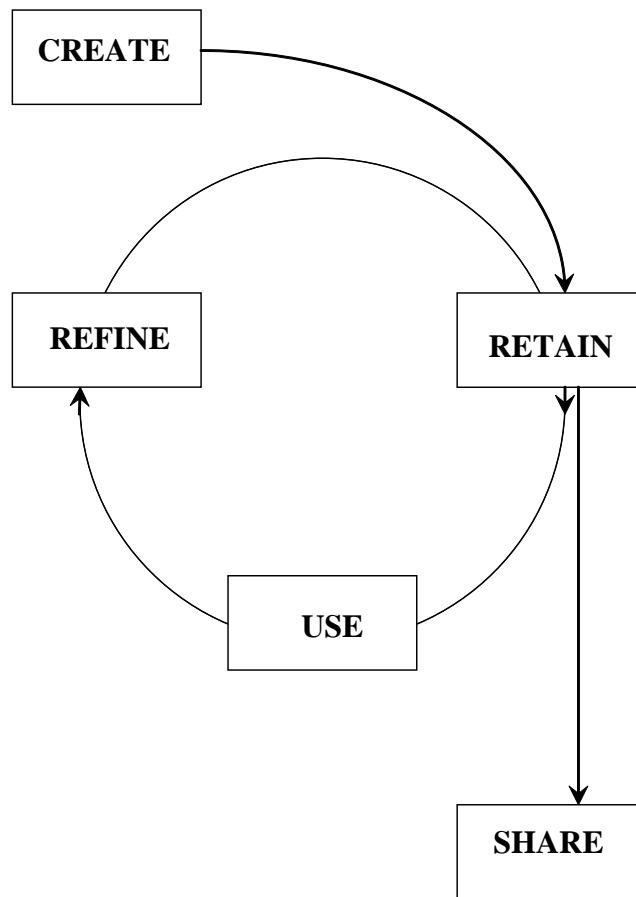


Figure 2

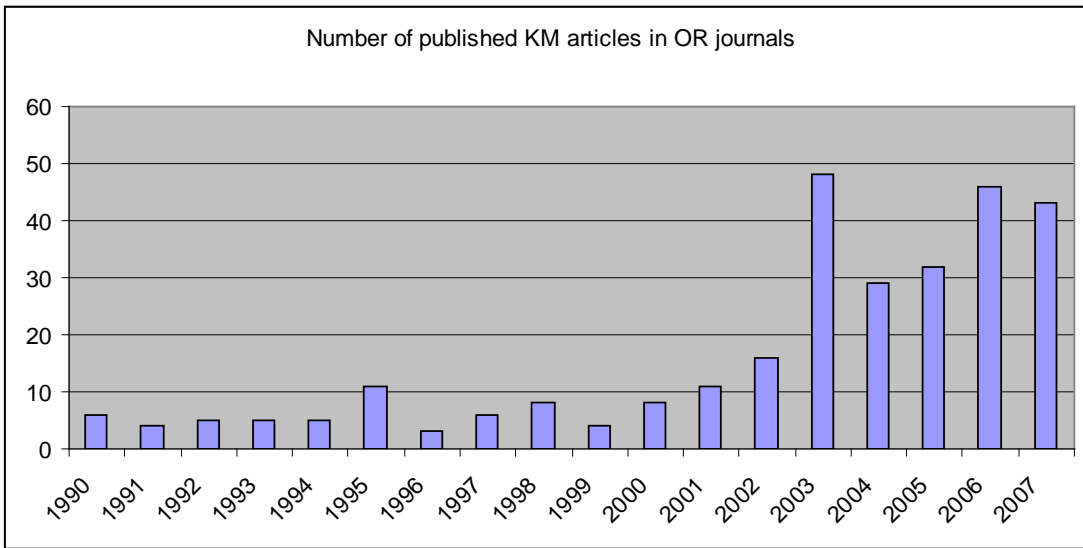


Figure 3

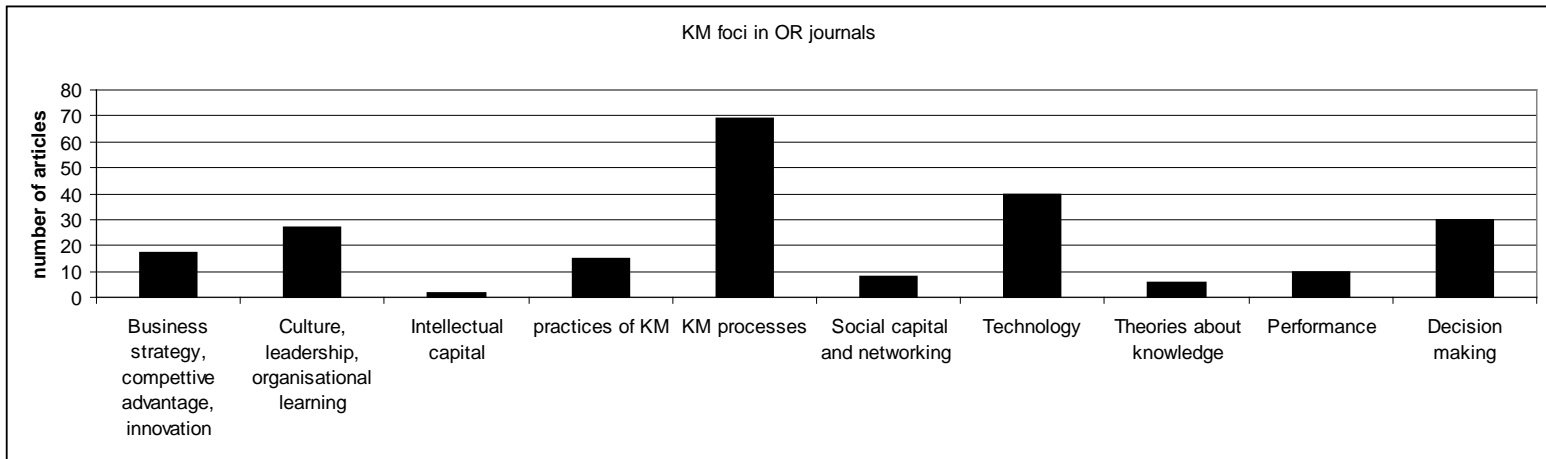


Figure 4

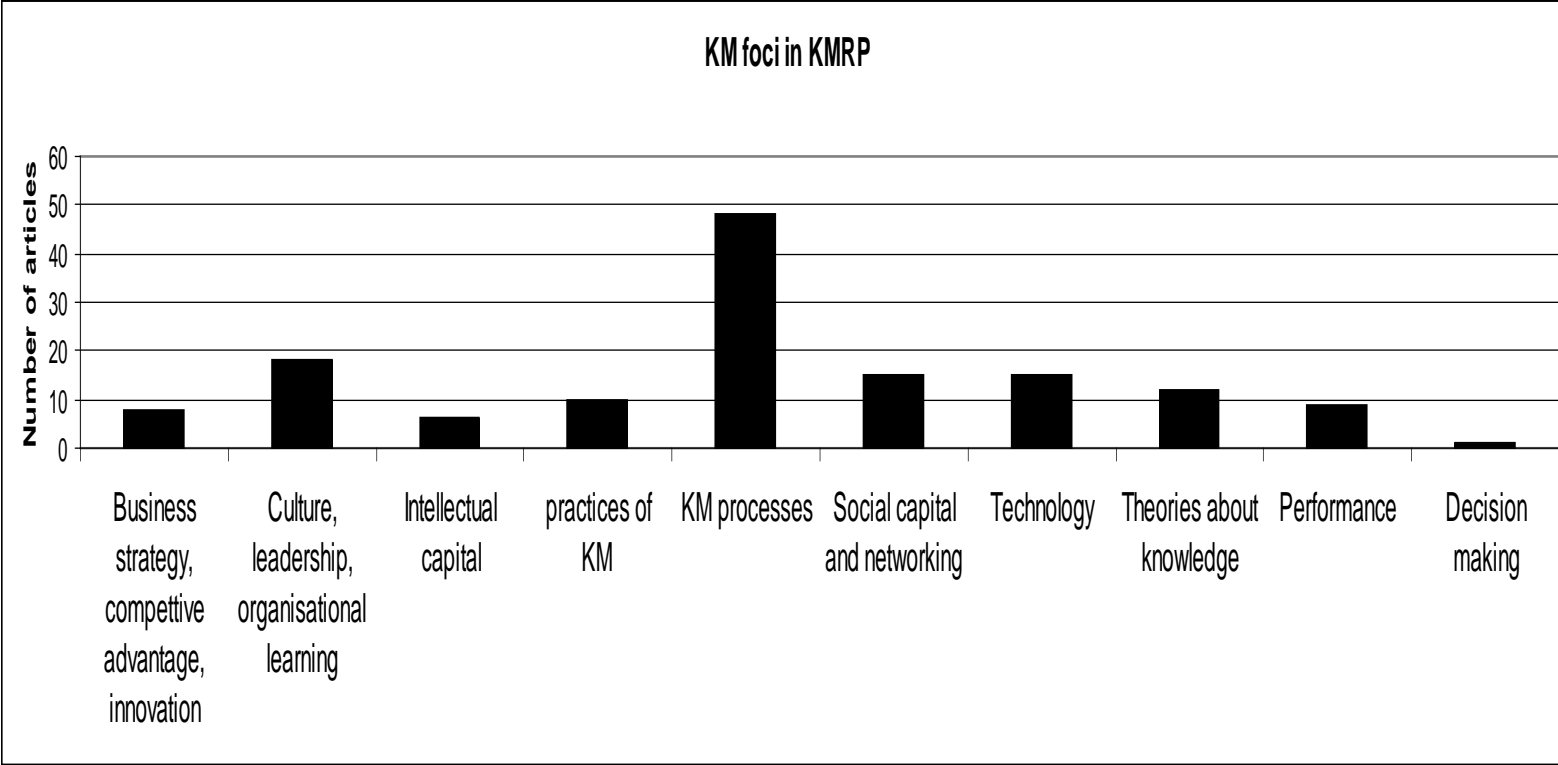


Figure 5

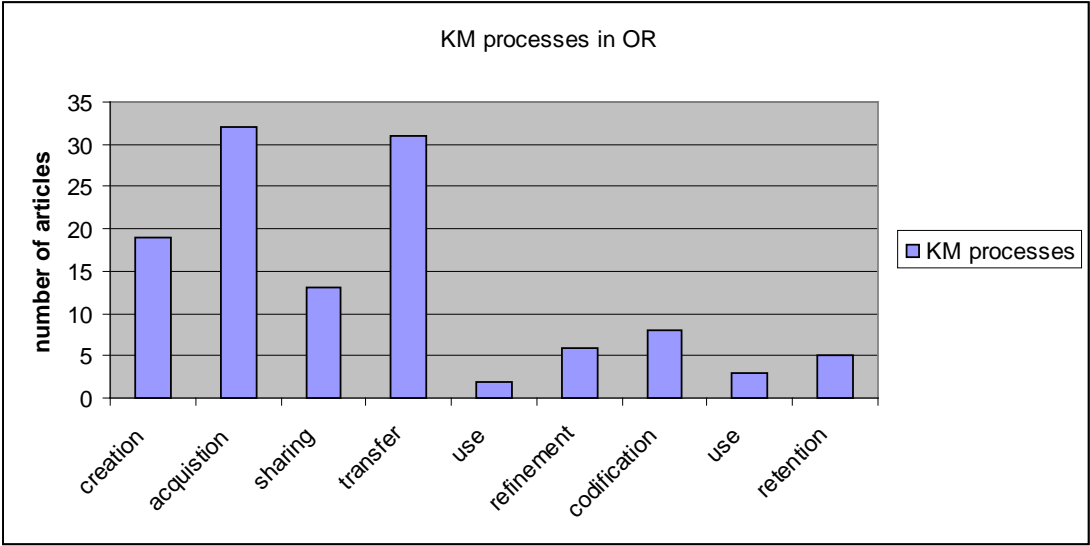
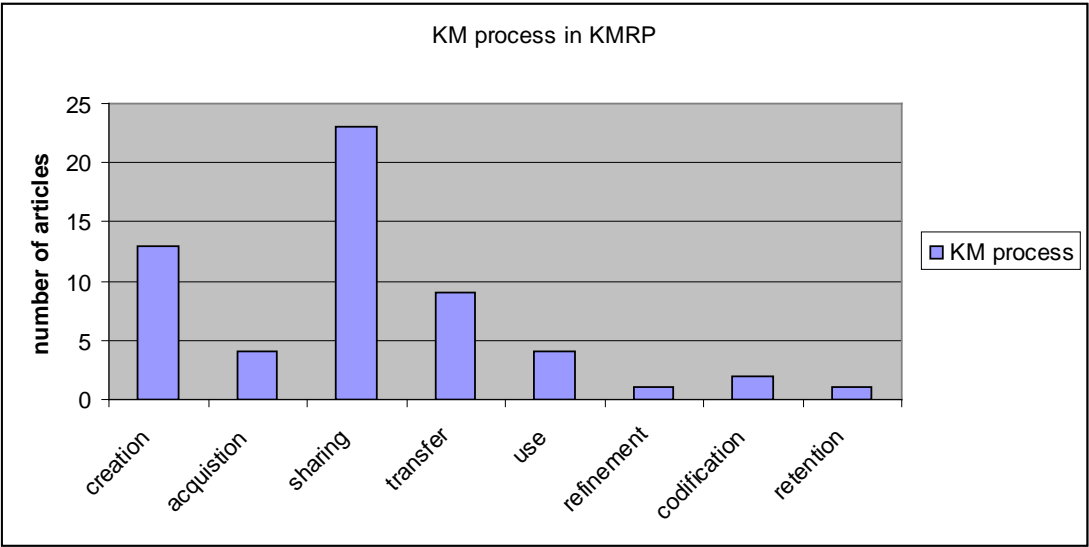


Table 1

1998	2007
Andersen Consulting (USA)	Accenture (Global)
Arthur Andersen (USA)	Apple (United States)
BP Amoco (UK)	BP (United Kingdom)
Buckman Laboratories (USA)	British Broadcasting Corporation (United Kingdom)
Chevron (USA)	Ernst & Young (Global)
Ernst & Young (USA)	Fluor (United States)
General Electric (USA)	General Electric (United States)
Hewlett-Packard (USA)	Google (United States)
IBM (USA)	IBM (United States)
Intel (USA)	Infosys Technologies (India)
Lucent Technologies* (USA)	Intel (United States)
Microsoft (USA)	McKinsey & Company* (Global)
Monsanto (USA)	Microsoft (United States)
Nokia (Finland)	Nokia (Finland)
Pfizer (USA)	Royal Dutch Shell (The Netherlands/United Kingdom)
Siemens (Germany)	Samsung Group (S. Korea)
Skandia (Sweden)	3M (United States)
Sun Microsystems (USA)	Toyota (Japan)
3M (USA)	Wikipedia (Global)
Xerox (USA)	Wipro Technologies (India)

(* = overall winner)

Table 2

First KM paper in an OR/MS journal (Basu, 1998)	November 1998
First Knowledge Management Aston Conference	July 2000
Triple stream on Learning Organisations and Knowledge Management at UK OR Society Annual Conference (OR42)	September 2000
Special Issue of EJIS	June 2001
Tutorial on Knowledge & Knowledge Management at INFORMS annual meeting, Miami Beach	November 2001
Special Issue of Organization Science	May-June 2002
Stream on KM and Intellectual Capital at IFORS	July 2002
First KM encyclopaedia (Holsapple, 2003)	December 2002 (<i>sic</i>)
Special Issue of JORS	February 2003
Special Issue of Management Science	April 2003
Stream at EURO XIX, Istanbul	July 2003
First issue of Knowledge Management Research & Practice	July 2003