EFFECTIVE KNOWLEDGE MANAGEMENT IN KNOWLEDGE-INTENSIVE ORGANIZATIONS

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Abstract[1]

This paper outlines an approach to determine the effectiveness of knowledge management (KM) in knowledge intensive organizations. 'Effectiveness' implies embedding KM processes in an organizational context. We introduce the Knowledge Governance Framework that includes knowledge resources, knowledge development, three types of KM, and organizational objectives. We applied the framework in two case studies to identify the three types of KM (operational KM, maintenance KM, and long-term KM), to determine what knowledge-intensive organizations regard to be effective KM and how they measure the effectiveness. Both cases indicate relations between 'use and development of knowledge resources' and 'business objectives', but the relations are managed only on a limited scale and on an ad-hoc basis. We found that KM objectives can be qualitative, implicit, and emergent (case one) as well as explicit (the use of business cases for portal investments; case two). We conclude with two hypothesis to be tested in further research.

Keywords: knowledge management, performance indicators, case study, business strategy.

[1] This paper is based on the METIS project, sponsored by the Telematics Insitute, Netherlands (www.telin.nl).

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1 Introduction

Knowledge is a remarkable substance. Unlike other resources, the value of knowledge increases instead of decreases when used (Shapiro and Varian, 1999). As a result, knowledge management faces a significant challenge: the more knowledge is used, the more valuable it becomes for the people and the organization(s) involved (Adler, 2002). Knowledge management is 'to identify, manage, and value items that the organization knows or could know: skills and experience of people, archives, documents, relations with clients, suppliers and other persons and materials often contained in electronic databases' (Davenport and Prusak, 2000: ix).

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Although a large body of literature exists on knowledge management (KM) in general (Wiig, 1995), and suggestions have been made to link KM to business strategy and business performance (Davenport and Prusak, 2000; Stewart, 1997), so far not much specific theory has been formed about the role that measurements and performance indicators play in KM. Some successful KM cases exist (e.g., Shell (2001) and IBM (Gongla and Rizutto, 2001)), but many organizations have still failed in their efforts to manage knowledge effectively (Choo and Bontis, 2002). Organizations have experimented with (IT based) instruments to stimulate knowledge development, such as e-learning tools, portals, communities, and document management systems. Despite promising findings, knowledge managers need more insight in processes of knowledge development to determine the business values of new technological opportunities.

The key question in this paper is how knowledge development and use can be managed effectively in an organizational environment. Swaak et al (2000) state that 'one has to *measure* in order to be able to effectively manage knowledge'. We note that this reflects a rather technical and formal perspective on management. Successful management can exist without the presence of clear and quantifiable indicators (Mintzberg 1973; Kotter, 1982; Wrapp 1984). So we might find that successful KM uses 'qualitative aspects' or even no aspects at all. Choo and Bontis (2002) address less explicit forms of KM when they indicate the importance of 'cycles of sense making, knowledge creation, and decision making'. Emergent and implicit forms of KM are also described by Ciborra and Andreu (2001) as alternative ways for managing knowledge required in different organizational contexts. No evidence is currently available on the effectiveness of using quantitative or qualitative indicators for KM.

Our objective is first to identify how KM exists in knowledge intensive organizations, what managers regard to be effective KM, how they determine effectiveness, and to identify the indicators that are used in KM. Ultimately, we aim to develop useful, practical guidelines for KM, more specifically on measuring and managing knowledge in knowledge-intensive, project based organizations, including their communities of practice.

This paper outlines an approach (the Knowledge Governance Framework) to the definition, measurement and use of performance indicators for KM in knowledge-intensive organizations. The approach links knowledge resources and instruments for knowledge development to KM, the organizational context of KM, and organizational objectives. The approach is based on existing typologies of knowledge (Nonaka and

Takeuchi, 1995; Boisot, 1998), processes of knowledge development and social learning (Senge, 1990; Nonaka et al, 2000), metrics for KM, like from the Intellectual Capital Method (Stewart, 1997), and the governance model taken from coordination theory (Malone and Crowston, 1994). Our contribution is that KM processes can now be embedded in an organizational context.

The paper is organized as follows. First, the Knowledge Governance Framework is outlined in sections 2 and 3. Then the framework is applied to two knowledge-intensive organizations to identify indicators for knowledge resources and KM (section 4). Section 5 lists lessons learned and conclusions.

2 Knowledge Governance

Governance comes from ‘kybernan’ (Greek) and is related to ‘cybernetics’ (Wiener, 1956), meaning ‘to steer’ and ‘keeping a ship on its course in the midst of unexpected changing circumstances’ (Peterson, 2002). Governance can be regarded as ‘control’ in a broad perspective, meaning that governance includes the total set of controlling activities that keep the system (ship, organization) on the right (chosen) course (Malone and Crowston, 1994). Governance is a purposeful intervention in order to achieve a desired output, and describes a subsystem of decision making units for directing and coordinating operational subsystems. The governance paradigm is based on a general systems approach of organizations (Ashby, 1956). Control in a limited perspective is related to directing one subsystem.

Knowledge governance (control in a broad perspective) is related to the total set of control, coordination and management activities in an organization, linking business objectives to knowledge resources. The knowledge governance framework is based on the following five conceptual building blocks.

(1) Knowledge resources and knowledge development. Knowledge is created in a continuous cycle, the well-known SECI (Socialization – Externalization – Combination - Internalization) model of cyclical knowledge creation (Nonaka et al., 1995, 2000), distinguishing between tacit and explicit knowledge that are continuously converted in a social learning process. Knowledge development does not happen by itself. To ensure that SECI processes can take place, Nonaka et al (2000) and Senge (1991) have defined certain necessary conditions in the form of guidelines for effective knowledge growth and development.

(2) Knowledge management. A common definition of KM is “The collection of processes that govern the creation, dissemination and leveraging of knowledge to fulfill

organizational objectives" (Ching Chyi Lee, 2000). Davenport and Prusak (2000) define KM as: 'to identify, manage, and value items that the organization knows or could know: skills and experience of people, archives, documents, relations with clients, suppliers and other persons and materials, often contained in electronic databases. We define knowledge management as 'purposeful interventions of knowledge development to realize sufficient knowledge availability at the time and place where the organization needs it'.

(3) Aspects to measure in KM. Management (or coordination) is based on measuring aspects. Knowledge management is based on measuring aspects of 'knowledge development processes' (Stewart, 1997), in the first place the SECI processes. If these processes cannot be measured directly, the knowledge resources that they produce and consume might be measured. Measuring knowledge resources is described in the Intellectual Capital method. The IC method identifies the relevant categories of intellectual capital, their critical success factors and metrics (Stewart, 1997). The method allows one to measure intangible resources, like knowledge and knowledge growth. The method first structures intangible knowledge, and, second, provides an adequate way of measuring knowledge. Its main distinction is between financial capital (monetary resources) and intellectual capital (intangible resources). In turn, intellectual capital is subdivided into human capital (the expertise of employees) and structural capital (intangible resources in organization).

(4) Indicators. As little research is known so far on what effective and efficient indicators in this context are, the approach in this initial stage was exploratory (Yin, 1994). As participatory observers, we let community members themselves define which indicators they thought to be effective and efficient. In future research these indicators can be compared with those found in other case studies, and improved using meta-criteria for indicator quality (Pipino et al, 2002).

(5) Diagnosis and feedback. After indicator values have been measured, diagnostic processes can be conducted to compare actual values with benchmark or target values. To conceptualize systemic breakdowns in the knowledge creation process, we adopt Senge's systems view on learning organizations.

How exactly knowledge resources (1) and KM (2) tie to strategic, tactical, and operational business objectives and workflow is often left implicit or not addressed at all. To specify these relationships, we have developed the Knowledge Governance Framework (figure 1), including measurement and feedback processes of the main knowledge aspects (3, 4, 5) for effective KM. Previous frameworks have been

published to link business objectives to knowledge resources. Gongla and Rizutto (2001) introduced the IBM Knowledge Management Framework 'to link or align a community with the organizational goals, management, value system, and infrastructure'. Another linkage between knowledge resources and business objectives is proposed by Lei et al (1996) and Katzy (2003) who see knowledge management as developing, maintaining and exploiting dynamic core competences and capabilities as the foundation for competitive advantage. We add to these models by identifying aspects and indicators and by distinguishing between three different but interrelated types of knowledge management activities, together regarded as knowledge governance.

3 Knowledge Governance Framework

We define knowledge governance as the process of controlling knowledge resources and knowledge development aimed at achieving organizational objectives. Knowledge development typically occurs in communities, where people work in a mix of project and other activities (Blackler 2002: p 63). Communities of practice (CoP) are playing an increasingly important role in modern, knowledge-intensive organizations. CoP foster knowledge development and creative interactions amongst highly specialized experts and help to channel their efforts to where they are most needed (Millen et al., 2002). In this way, CoP are a key element in knowledge development (Wenger et al., 2002).

In projects, a mix of experts works together for some time to create a product or service that meets some customer requirement. Project members can come from the knowledge resources of the service providing company, the client organization, or other –external- sources. After the project, participants return to their 'home base' adding the knowledge acquired in the project to the 'shared knowledge resources' of the community. How to effectively manage knowledge in communities of practice in a project environment is an open question.

The Knowledge Governance Framework defines the organizational and management context of knowledge resources and distinguishes between three levels of KM in the organization, based on the temporal scope and organizational level that governs it. For example, in a short-term perspective, it can be efficient to combine specialists (knowledge resources) into one department when making complex products, such as jet engines (Smith: in Choo and Bontis, 2002). This type of specialization increases short-term efficiency of *knowledge creation and knowledge storage*, but also increases the costs on longer term for *knowledge transfer and integration* with other specialists.

KM practices may be short term effective as well as long term suboptimal to the organization.

Figure 1 shows -at the bottom- the knowledge resources and knowledge development in an organization. The central part of figure 1 shows the three levels of operational, maintenance, and long-term KM, their relations, and the relations with organizational context (customer needs; products and services of the organization; business strategies). Relations between the three levels consist of indicators (in reports or 'maps') and corrective actions. A map is a collection of relevant indicators of knowledge resources to be used in a KM process. Figure 1 also shows examples of indicators.

Operational KM. An operational knowledge manager takes care of the customer demand for knowledge-intensive products or services and forms a project team consisting of knowledge resources and specialized employees who will implement these orders. A customer need can be a request for financial services (an 'investment fund') or an information system to manage insurance claims (by insurance intermediaries). After a request has been received, operational KM needs an availability map, an up-to-date overview of the free and available knowledge resources to be able to create optimal project teams. If there are differences between the actual needs of Operational KM and the available resources, the gaps will be communicated

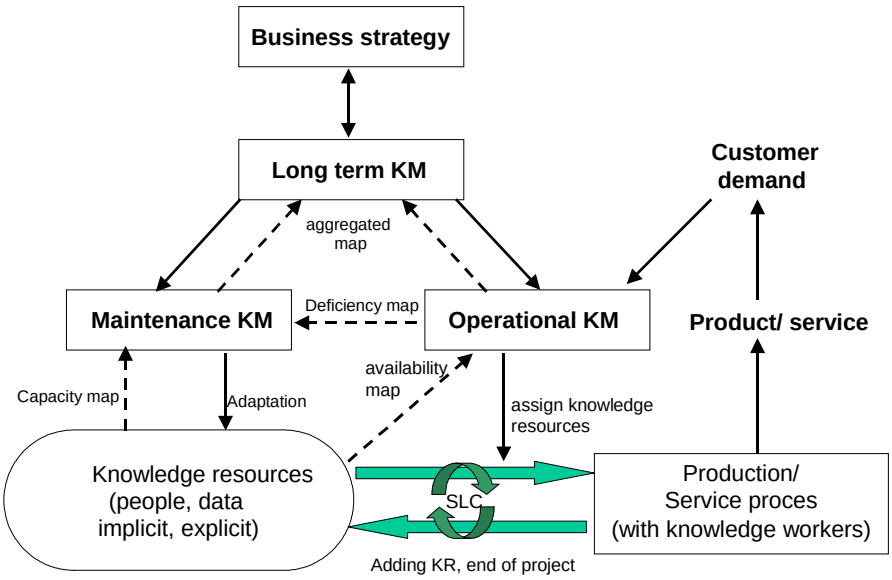

Fig 1. The Knowledge Governance Framework.
(SLC = social learning cycle)

to Maintenance KM, for instance in the form of a deficiency map.

Maintenance KM. A maintenance knowledge manager aims to maintain an optimal level of knowledge resources by comparing the capacity map (all or part of the total set of knowledge resources present in the organization) with the deficiency maps and long term plans. As a result, the knowledge resources may be adapted, for example by training or hiring human resources or buying, developing knowledge products, stimulate social learning, and linking to other resources. Operational and maintenance knowledge management are represented as one function. All types of knowledge management will be executed by multiple persons and departments in most organizations.

Long-Term KM. A long-term knowledge manager evaluates maintenance and operational KM, based on reports, indicators, business objectives and strategies, so that a long-term plan can be made. These plans are communicated to the other KM processes and contain the KM objectives to be reached and the costs and profits that will be realized. Many organizations claim that knowledge resources are the core building blocks for creating customer value, and that knowledge and competences ought to be explicitly managed (Zack, in Choo and Bontis, 2002: 255). Zack found (after researching 25 companies), that the firm's strategy is the most important context to guide knowledge management. He distinguishes between a *strategic gap* (a gap between what firms must do to achieve their goals and what it can do) and a *knowledge gap* (a gap between what a firm must know to execute its strategy and what it does know). Long term KM can be regarded as aiming to reduce both gaps within business constraints.

Grover and Davenport (2001) edited a special issue of the Journal of MIS on Knowledge Management, fostering a research agenda. They distinguish between a *process framework* and a *market framework* for knowledge management research. The process framework is a pragmatic one in which the knowledge generation process (including codification, transfer, and realization) is used to guide research on 'how knowledge creation and use can be managed'. The market framework takes a transactional perspective where knowledge exchanges occur in a market place (Davenport and Prusak, 1998). The market framework uses concepts such as information asymmetry, efficiency of markets, and standardization, thus framing knowledge management as the problem of creating an effective and efficient knowledge marketplace. The knowledge governance framework fits the process framework since it focuses on how knowledge creation and use can be managed. The

framework might also fit the market framework in the sense that knowledge resources (in a community of practice) are represented to various knowledge managers (using different maps) in different business positions, thus creating markets for knowledge exchange. We check this to some extent using questions 3-5 (see below).

The knowledge governance framework is operationalized with a questionnaire consisting of five open questions to be applied in interviews with managers in case studies. The five questions are:

(1) What do you regard as the key knowledge resources in your company?

(2) Which communities (of practice, interest or others) are important for your company?

(3) With respect to Operational KM:

- Who decides which (knowledge) resources will be assigned to a project (customer/ product/ process)?
- How does this person determine the amounts and types of resources needed? Which goals does she want to achieve? How are the goals evaluated?
- How is the availability of (free) resources indicated? Which are the indicators for available knowledge?
- In case of lacking or insufficient resources: how and with whom is this communicated? Does your company (managers) use specific threshold values for resources?

(4) With respect to Maintenance KM:

- How are knowledge resources created? Who maintains the resources, and how does maintenance take place? How is the availability of resources indicated?
- With whom does communication take place on necessary knowledge resources? What are the objectives of these people?
- In case of lacking, insufficient (or excess of) resources: how and with whom is this communicated? Does your company (managers) use specific threshold values for resources?

(5) With respect to Long term KM:

- How is KM linked to business objectives and business strategy? (e.g.: Why did your organization start (or stop) intranet, a portal, a community of practice?)
- How is the availability of knowledge resources indicated on the organizational level? In case of lacking or insufficient resources: how and with whom are

these communicated? Does your company (managers) use specific threshold values for resources?

The questionnaire was used to determine how knowledge management is implemented in an organization, which indicators are used, which communication occurs between management levels, and how KM technologies are valued and implemented. When this analysis of KM in an organization reveals the absence of indicators or communication between levels, this might be a reason for management to take action.

Methodology

We did in depth analysis of two cases. The case study method was used because it enables "reality" to be captured in considerable greater detail than other methods, support the exploratory stage of research, and also allows the analysis of a considerable greater number of variables [Yin, 1994]. The use of case studies as a basis for drawing inferences about a particular area of study is related to an interpretive epistemological stance [Walsham, 1994]. From this perspective the validity of an extrapolation from one or more individual cases depends not on the representativeness of such cases in a statistical sense, but on the plausibility and contingency of the logical reasoning used in describing results from the case, and in drawing inferences and conclusions from those results [Eisenhardt, 1989; Orlikowski and Baroudi, 1991].

Interviews have been done –based on the five questions- with two managers that are responsible for (part of) the KM in each organization. All interviews took place in 2003. Web and other documents were selected and used to prepare some questions that particularly focus on the KM practice (i.e., examples of technology applications) in the organization. A report was made covering the answers to the five interview questions. The report was checked by the interviewees and then used for further case analysis, based on documents, web, and desk research (Yin, 1994).

4 Applying the framework in two cases

The framework and questionnaire was applied to two cases, FP and EP. Both cases are knowledge intensive firms, but are considerably different in size. Both firms fit the category ‘low volatility context’ and are ‘product based’ according to Kankanhalli et al (2003).

4.1 Case FP

Case FP is a young and small company (20 employees) in the financial service sector. Core activities of FP are the design, manufacturing, and exploitation of investment funds (particularly 'hedge funds'). Investment funds are highly complex and knowledge intensive products with many specialized roles related to securities trading, such as brokerage, portfolio management, fund accounting, administration, and custody. FP acts as an intermediary in this web of roles or executes roles. FP designs, makes, and exploits investment funds for her customers: large financial institutions like pension funds and banks. FP has a large international network of financial experts and service providers for all activities involved in fund creation and management. FP has also developed its own portal and an automatic text categorization system to filter the enormous daily flows of information and news and to create practical reports and selections. The portal is used to support FP experts in the development of funds. Until June 2003, the portal was also made available –for a fee- to external users.

Key knowledge resources and communities

FP distinguishes between five knowledge resources:

- *Knowledge related to FP products*. FP has much implicit knowledge on three product types ('traditional funds', 'structured funds', 'hedge funds'). FP maintains a large database of explicit knowledge covering the business details of all hedge funds of a special type (600 funds). Databases with explicit knowledge on (all or a parts of) the 65.000 funds in Europe are for sale but FP is not planning to buy these.
- *Knowledge on the production of funds*. FP keeps explicit knowledge in small databases on custody services (there are only about 5 custody service providers in Europe), fund administrator services (there are only about 30 service providers in Europe). FP also maintains papers and manuals as explicit knowledge on 'how to make an investment fund' etc, also known as 'soldier's handbook'.
- *Knowledge in people* (personnel). FP distinguishes between experts with 'product related knowledge' and experts with 'process related knowledge'. Product experts cover one of the following fields: 'hedge funds', 'structured funds', and 'traditional funds'. FP has process experts covering one of the following fields: fund administration, custody services, IS/IT services, risk management, treasury management, and legal services. All experts have valuable tacit knowledge on the selection of external experts in specific

(financial) domains, and knowledge covering the first two categories of knowledge resources. This tacit knowledge supports 'make or buy' decisions for financial products and services in FP ('will we do a service ourselves, or do we buy it on the market').

- *Knowledge on customers*: FP keeps a large database (explicit knowledge) on its customers (pension funds, banks, integrated asset managers), including emails, letters, contacts etc, to enable reports on customers and on processes, such as 'status of leads', 'current and previous relations', 'status of the order pipeline or projects per customer' (CRM).
- *Knowledge of financial markets*. The market of making and selling funds is an example of a slow market: large financial institutions ask for special financial products and services, and allow providers like FP enough time for product design and development. FP has structured the knowledge on the financial industry in more or less fixed themes that form the basis for the FP database (portal) and the automatic text categorization (explicit knowledge).

The only real community (of practice) in FP is the internal network of experts. There are no communities between FP and its clients or communities around products or processes, no communities around literature, and no living discussion groups on financial themes relevant to FP. Most external relationships are characterized by single channel client-provider communication. FP has some internal and external mechanisms for knowledge development, a community of practice and a portal for internal (and until June 2003 also for external) use.

Operational Knowledge Management

FP distinguishes (like many other organizations) between customer related projects and product push projects (internal projects). The two project managers in FP assign resources to customer related projects. The product group assigns resources to product push projects, but when resources are scarce, these projects wait in favor of customer projects. Allocation of resources to projects is an informal process in a small company like FP, without using cv- or history matching techniques. Knowledge resources are lacking, for instance when hypes occur in the FP markets. Recently, FP has decided not to include financial hype themes in the portal-database; in other words, FP has decided not to restructure its *explicit* knowledge, not to hire hype-experts to expand human resources, adding *tacit* knowledge. FP has concluded that the best business chances would come from using the available resources (= existing database themes and existing experts).

Maintenance Knowledge Management

Different groups and actors in FP maintain the five knowledge resources listed above. Knowledge of FP products and processes are created and maintained by the FP experts (knowledge workers). Knowledge in personnel is maintained by FP management, by making hire and fire decisions. Knowledge on customers is maintained in a database by experts and support staff. Knowledge of financial markets is maintained almost automatically by using automatic text categorization of large amounts of external data. Communication on the necessity of knowledge resources takes place within the FP community of practice in socializing processes.

Long term Knowledge Management

FP aims for high product quality, not for low costs. The portal use was satisfactory at about 100 hits per day (internal and external) and about 200 (external) subscribers. The portal-related newsletter covering the top-stories in the portal and fund-bytes (interesting quotes) was sent to 120 addresses each week. FP has stopped the newsletter and the automatic updates of the external portal per June 2003. The web site it self was not stopped, because news is still categorized, stored, and used by FP internally. Only the external portal services have been stopped, because the portal did no longer support business objectives: (1) markets are difficult for portals nowadays, (2) the services did not contribute directly to the sales of funds, (3) the revenues from portal subscriptions did not sufficiently help to cover the costs of portal development. FP still keeps its portal and web site including material and information on various topics, but without the updates.

FP uses customer contacts like client reactions; subjects of seminars, to find out ‘hot issues’. Last year it appeared that there was a growing interest in alternative investment instruments. This did not result in the (long term) decision ‘to put a new filter in the Smart Haven search engine’ that would change the automatic text categorization for the portal. It did result in a set of individual searches on this subject in the existing knowledge base without changing the structure. The answers were then used to present reflections on ‘hot issues’ to the customers.

In summary, the three levels of knowledge management can easily be distinguished, as well as the key aspects for those levels. Quantitative indicators in FP KM are rare. Diagnosis occurs ad hoc.

4.2 Case EP

Case EP is the division Exploration and Production of a large company in the oil industry with branches in 40 countries worldwide. EP has 15.000 employees. Core activities of EP are ‘searching for oil fields’, ‘investigation of oil fields’, and ‘producing oil’. Oil companies recognize exploration as a (key) source of competitive advantage because drilling is such an expensive undertaking (Kankanhalli, 2003). Much knowledge on oil locations and drilling resides as implicit knowledge in many professionals and experts in many different locations around the world. Other knowledge is explicit and available in many databases and portals, based on a variety of technologies to support knowledge creation and use in various groups, teams, and communities.

Key knowledge resources and communities

People are regarded as the key resource in EP. When an employee leaves, EP uses an exit procedure: the personal network and key documents are stored. The KM objective of EP is to store human (TACIT) knowledge in databases (EXPLICIT) so that it can be used also after the people are gone. Many employees move to new positions, people often stay only 2-3 years in one position, leave the company, or retire. Human/ tacit knowledge is thus typically constructed over a period of three years. To preserve this tacit knowledge, at least some part of it must therefore be transformed into EXPLICIT knowledge, distinguishing between:

- Knowledge on personal networks (informal and formal). An example is the worldwide ‘who-is-who in EP’ system.
- Knowledge on procedures and working processes, stored in a global document system (GDS), covering many EP documents, including geographical maps, and various links with internal and external libraries and information providers.

The data resources are centralized in the libraries and made accessible through the portal. Given the massive amounts of data available, it is impossible to manually index the collections. Key in making the libraries accessible is the thesaurus, which acts as a kind of ontology. Thus, measurement efforts are focused on thesaurus completeness and accuracy, and use. Indicators of knowledge resources and development are the numbers of queries, query refinements, index links to particular thesaurus terms, changes in thesaurus, thesaurus terms unused, jumps between libraries, the most popular items in employee portal instances, and the types of customizations of portal defaults

Human resources are key. The focus is not so much on individual but on joint performance. The contact networks of employees are strategic resources. Collaboration in the project teams and the communities of practice is essential for the success of the corporation. These communities are self-organizing. Indicators of knowledge resources and development are the employee contact maps, the results of social network analysis (defining properties such as who are central nodes, linking pins, specialists in networks), FAQs, mailing list indices based on thesauri and ontologies, the numbers of messages sent to list (as indicators of success/ overload of network), the number of messages related to topic (as indication of potential need for forming new communities/teams).

EP has twelve on-line forums ('communities of practice') with in total 23,000 members, in many closed and moderated discussion groups. The forums are used to support the formation of project teams and to obtain quick answers on current issues.

EP aims to get employees worldwide to communicate. Therefore many tools are used. Explicit knowledge resources came into existence many years ago with external on-line information providers, which have since then transformed into 'one' (logical) library, including search engines. In 2000, a project was started to create a '*global virtual library*' with a portal as a tool for access and database integration. Currently also '*external factual on-line services*' are provided. These have been integrated into an XML based data search environment on 'business information', 'information on competitors, sister-organizations, and countries'. Portals are a special type of tools. EP uses portals to support expert teams by letting them share a diversity of data, documents, maps, and photographs.

- The Discovery.com portal was introduced in 2003 to enable staff (geoscientists and well engineers) to share subsurface and well-related data and documents across three 'operating units'. The portal was originally developed in 2000 on a smaller scale and scope, with limited functionality for one EP cluster. Early 2002, the scope was widened and users from two other clusters were included. Further roll out took place in these two clusters in 2003. The portal provides access to well and petroleum engineering information, geological, geophysical, and production data. Users can search for fields, well bores, seismic and concession data. It also has a link to document management systems and contains a geographical information system to show maps on which users can select an area and see the wells in that area. Main benefits of the portal are reported to be 'harnessing and

harmonizing knowledge by giving users access tot data rapidly', 'enabling important data to be shared', and 'making the community feel connected, while they are in three locations and are supposed to work together and share information'.

- EP-one portal is another portal with extended functionality and approximately 3000 users in 2003. The objective of the EP-one portal is to become the main entrance to all EP knowledge resources and communities. The business driver for the portal is 'to improve and accelerate decision making in EP and increasing business results' (in the form of better drilling results and development of new techniques).

Key tools and resources for portals are a mix of old (who is who and email) and new technologies, including 'sniffers' to perform automatic XML-indexing of documents. The taxonomy basis is a thesaurus which was linked in 2003 to individual user profiles; and an attribute model with 50 elements as coordinates (GIS), copyright, retention date, export control. Scalability of a portal is not a big issue. Only much –but not very expensive- extra hardware is needed (in addition to the existing EP infrastructures), but logical flaws in information retrieval are not known. The portal is scalable up to over 100,000 users by using user profiles, role-based filtering, and defaults.

The number of interrelated portals in EP is remarkably high. Portals are regarded as interfaces between data sources and many different users, each having an individual profile and information needs. To be effective a portal must have many (or at least a certain number of) users. Some technologies used to increase the user base are the EP Global Infrastructure Desktop (worldwide standard interface components), Single logon, Distributed federative search, Unified database connection, Filter and alert, Integrated reporting, Drag and relate, user and location dependent accessibility, role-based functionality, and portal tools like search engines, taxonomies, knowledge bases, user profiles, etc.

Operational Knowledge Management

Operational KM in the sense of assigning knowledge resources to business activities, traditionally takes place in business clusters by Vice Presidents or cluster managers. With a change in organizational structure to matrix models, the role of discipline heads was introduced. They are responsible for assigning staff to *projects* and *staff development* in operational entities. Discipline heads keep track of resource availability. Project teams are created by using the 'Orchestra' application, which also helps to track progress of projects and supports exchanging documents. Typically

projects have 10-20 people and run for about two years, depending on the project focus and type. Processes are in place to list, evaluate, and prioritize project proposals by EP management (for example a process known as the Business Aligned Architecture). Added value of projects is determined through workshops with the business units.

Operational KM takes place by various managers. Information from the Orchestra tool can be helpful in calculating availability. Indicators for KM are (per employee) the numbers of unplanned hours in next month, the numbers of projects involved in, self-assessment of hours available in next month, and (per project) the numbers of budgeted hours per stage; the numbers of participants, and the average available hours of participants.

Maintenance Knowledge Management

Maintenance KM concerns maintaining an optimum level of knowledge resources. This calibration takes place in different ways. Skill pool managers manage the competences of EP staff together with the Human Resources function. They are responsible for overall staff availability, staff development together with the Learning & Development function and career prospects. Staff development is appraised at least once a year against a Competency framework, and development tasks and targets for each individual defined for the coming year. When staff/ engineers leave, user profiles are created and audit trails of problem solving sequences are recorded. New personnel can be trained faster (1 month instead of 1 year).

EP stimulates the usage of portals by ‘selling’ a portal to the business clusters and by creating short tailor-made reference guides and introductory courses. Usage is measured by simple indicators such as ‘the number of searches’ and ‘the frequency of searches’.

Maintenance of portals is relatively easy and does not use many resources. Hardly any format changes are made in practice on the database level. Another maintenance role is fulfilled by ITCT, this is the IT competence centre giving global IT support for KM, specifically for portals. Portal maintenance uses the ‘beep system’: corrections are only done when users start complaining about data quality, interfaces, and/or performance. The help desk then contacts the database owner. Complaints come in irregularly: on average 1 help desk call per hour. The Portal steering group and the Enterprise portal program management can be regarded as roles in maintenance knowledge management.

Long term Knowledge Management

A governance body is in place for EP, which provides the basis for a single global KM process, relevant global standards and best practice identification, dissemination and assurance. Additionally, portfolio boards ascertain alignment with overall business objectives and strategy. Global business workshops are used in EP to decide on projects and go/ no go once per year in each business unit.

As an example of long term KM we give the EP portal business case. The portal proposal was first based on recommendations made by a study, which assessed the efficiency and effectiveness of Knowledge Management in EP: two groups of knowledge workers had to answer a question, one group supported by the portal, the other group without portal support. The portal supported group needed only minutes to give a perfect answer, the other group needed several hours. General management then requested further evidence of the business value of the portal before deciding on implementation. A pilot experiment with 200 EP users, showed savings of at least 10% personnel. In total, eight business cases were made for the EP-one portal. 3D graphical outputs are regarded to be one of the key values of the portal. Also, the portal helps to reduce costs for the use of external databases and helps to train new personnel much faster. Training time is now about 1 month and the productivity of personnel in the first year has doubled! EP has developed and uses user satisfaction indicators to evaluate portal quality. Portal costs are measured as costs per user per year (120$, of which 35% is for support, 35% for licenses, 18% for hardware and 12% for overhead) and time savings in operations (hours per person).

Summarizing, EP is a large knowledge intensive firm, operating on a worldwide scale, and focusing on the development and use of knowledge to find and win oil. Much knowledge is implicit and resides in many experts and professionals; other knowledge is explicit and available in the form of very large databases. Various communities flourish in EP, also linking EP to external groups and resources. EP uses a variety of technologies to support knowledge development in communities. Investment decisions in portals show how EP uses business objectives to evaluate the value of knowledge development. Three types of KM can be distinguished in EP.

5 Discussion and Conclusion

We investigated how KM exists in real cases, and focused on what managers in two knowledge intensive organizations regard to be effective KM and how they measure effectiveness, and how they use indicators. A summary of findings in the two cases is given in table 1.

Table 1. Comparison of knowledge management in two cases, using KGF.

KGF aspects	Case FP	Case EP
organization	Small (20 fte) Product based (investment funds) Low-volatility Local/ national scale	Large (15.000 fte) Product based (better drilling, exploration) Low volatility Global scale
Knowledge resources	1. Products (funds) (I+E) 2. Production process (I+E) 3. Personnel (I) 4. Customers (E) 5. Financial markets (E)	1. People (experts) (I+E) 2. Personal networks (I+E) 3. Procedures and processes (E)
Communities	One internal community (face to face)	Twelve on-line forums (23,000 members) to support project formation and obtaining quick answers
Operational KM	Customer related projects (priority) Product push projects Stable content of knowledge portal	10-20 people per (often virtual) project Problem solving projects Innovative projects Personalization of a variety of portals Explicit processes for project selection
Maintenance KM	One (large) portal is maintained 1 and 2 by experts 3 by FP management 4 by experts and support staff 5 automatically (text categorization)	Many interrelated portals are maintained Low cost portal maintenance (120 $/user/yr) Skill pool managers (HRM) Competency frameworks Exit procedures when employee leaves
Long term KM	Aims for product quality (not for low costs) Portal value is evaluated qualitatively for internal and external objectives External portal was stopped because it did not support core business goals Market developments are followed implicitly and explicitly (automated scanning)	Single global KM process Global standards Best practice identification Portal proposals including business cases Knowledge processes evaluated on business performance indicators

We found that *KM exists in both cases*. Managers in both companies can list the key knowledge resources and, after some reflection, processes of knowledge development. Both companies also show examples of operational, maintenance, and long term KM, but without clear linkages between these three types and also without explicitly linking knowledge resources to company objectives or business strategies. Linkages between knowledge resources and operational objectives are made in some project decisions. Linkages with business strategy are created on a more or less ad hoc basis, for example when investment decisions for portal development are taken.

We found that *KM does not have a clear organizational position* in both cases. KM appeared to be mixed with business operations, objectives, and strategy, as well as with technology development, information services and human resources management. On the one hand, knowledge development and deployment form the core of business operations, being the responsibility of business managers. On the other hand, availability of knowledge resources in the form of portals, libraries and databases, is regarded to be the responsibility of technology managers. KM is divided into tasks 'development and maintenance of technologies' and tasks regarding the 'development of knowledge in the business activities'. Successful knowledge governance seems to depend on good functioning and the alignment between these two tasks. This resembles the classic information management challenge to align IT services and business needs in the well-known strategic alignment model (Henderson and Venkatraman, 1993).

After concluding that KM exists and that it does not have a clear position in the two cases, we tried to answer (1) 'when is KM effective?' and (2) 'are measurements necessary to realize effective KM?'

We found that the answer on '*when is KM effective'* depends on the level of KM, as given in the knowledge governance framework. Effects of KM can be evaluated on (at least) three levels:

- The operational level: is the project successful (FP, EP), did the experts learn from each other (EP), do the communities develop (EP), and (on a department level) are knowledge resources used (FP, EP),
- The level of maintenance KM: are the portals and databases used (FP, EP),
- The level of long term KM: the business cases to decide on portal development (EP) and portal valuation to decide on continuation (FP).

Effectiveness of KM is (by definition) the degree to which objectives are fulfilled. Obviously, KM can be effective on one level, without being effective on other levels. Effective KM on an (overall) organizational scale implies the need for balancing between achieving short term and long term objectives, and balancing between objectives in different business and technology domains. Examples were found in the two cases (the portal decisions in FP and EP; the community development decisions in EP).

A key issue that still needs to be addressed is to relate the analysis of the effectiveness of KM in more detail to indicators of effectiveness of the organization.

We are currently following up on the case studies by studying in more depth with respect to types and quality of measurement processes used. We are also applying our knowledge governance framework to a mid-size company.

Are measurements necessary to realize effective KM? Measurements in the sense of 'determining quantitative values over periods of time' were not found for most aspects of knowledge resources, knowledge development, and KM. We found that KM objectives can be qualitative, implicit, and emergent (FP) as well as explicit (the use of business cases for portal investments in EP). Not surprisingly, there seems to be much larger need - and more possibilities - for measurement in the EP than in the FP case. This can be explained by the larger size and virtuality of the EP organization. Since the need for quantitative measurements might depend on the size of the organization and the KM level, we propose that for successful KM sufficient attention must be paid to the selection of key aspects, instead of trying to measure everything.

The *measurements are a mix of quantitative and qualitative measures*. Basic quantitative indicators play a role, but only an auxiliary one. Many measures are of the 'story' type, in the form of lists of objectives, project summaries, etc. However, in combination with (task-dependent) numerical indicators, powerful measurement instruments could be designed that directly influence workflows and business decision making. Still, much of the potential has not been realized yet, partially because the required data resources and information technologies have only recently started to mature, partially because the theories for pervasive KM at and between all levels (operational, maintenance, long-term) are only now starting to be developed. However, in the interviews, the need for experimentation and implementation of new, more sophisticated measurement instruments of the kinds illustrated has been clearly expressed.

Our findings suggest that *effective KM can result from informal forms of management*, with explicit measurements in a supportive role only. This is in accordance with Choo and Bontis (2002) and Ciborra and Andreu (2001). One partial explanation is that people find the definition, refinement, and use of sophisticated domain descriptions difficult and insufficiently beneficial. Therefore, they will focus on a locally useful amount of structure only (Marshall et al., 1995). KM approaches should aim for supporting such natural tendencies. In line with developments in the data quality literature, subjective (informal) and objective (quantitative) measurements should be better aligned to arrive at higher levels of validity and reliability (Pipino et al., 2002).

We advice further research to find the conditions in which implicit and explicit coordination mechanisms for KM lead to success. We advise further research in knowledge-intensive organizations, varying in size (small, medium, large), varying in KM (implicit versus explicit in different management levels), and with business results being the dependent variable. Before conclusions can be drawn on 'how to realize effective KM', it is necessary to relate the analysis of the effectiveness KM to indicators of the effectiveness of the organization.

Hypotheses to be tested in further research are (1) KM in knowledge-intensive organizations can only be successful if KM links knowledge resources to organizational objectives, and (2) successful KM can only exist if explicit, quantitative indicators are used.

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