Knowledge-based manufacturing enterprises: evidence from a case study

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Abstract

Purpose – The purpose of this paper is to study how managers in manufacturing firms approach the challenge of knowledge management in their organizations.

Design/methodology/approach – The research methodology is an in-depth case study. The empirical data were collected from an international oil and gas manufacturing company operating in more than 30 countries and leader in Spain and Argentina. The purest form of a longitudinal field study, daily participant observation, was feasible as one of the authors is an executive at the firm studied.

Findings – Based on the field investigation, the paper presents the process followed to build a knowledge vision in the company, the first stages of the initiative, the development of new projects, and the lessons learned resulting in the creation of a knowledge management unit, a working model, a strategy, and a set of different projects that were on the basis of the competitive advantage of the organization.

Research limitations/implications – The perspective proposed in this research should be viewed with some caution, because of the methodological limitations of the present study as the paper drew on detailed descriptions of one organization. The extent to which the local explanation presented develops into a more general framework depends on how well it, or its descendants, explains the "phenomena" in future work.

Practical implications – Analyzing knowledge management initiatives in manufacturing companies becomes of major interest as it is relevant to further explore how this initiative can help optimize production processes and integrate operational requirements with enterprise-level decision-making processes as well as it adding value to customers in the industry at various stages of the value chain such as exploration, in-bound logistics, technological operations and out-bound logistics.

Originality/value – The paper is practical in nature and reports on the managerial applications and experiential implications of the matter of study. The research shows the main findings and discusses the main implications as well as future lines of research.

Keywords Knowledge management, Oil industry, Gas industry

Paper type Case study

Introduction

Certain environmental forces, such as globalization, deregulation, and technological innovation, among others, create opportunities and threats to firms in different countries, and have the potential to erode the competitive advantage of firms, countries, and regions (D'Aveni, 1994; Illinitch *et al.*, 1996; Prahalad and Hamel, 1994). What can firms do to mitigate threats and take advantage of opportunities in such a context? Nonaka and Takeuchi (1995) argue that, in an environment where the only certainty is uncertainty, the only real source of sustainable competitive advantage is knowledge.

Having witnessed an increased amount of papers in strategic management addressing the major concern of how managers can best leverage the knowledge base of their organizations to build competitive advantages for their firms (Galunic and Rodan, 1998; Grant, 1996; Kotha, 1995; Liebeskind, 1996; Spender, 1996; Tsoukas, 1996; von Krogh *et al.*, 1994), we observe however that more theoretical and research efforts focusing on the "how companies actually do it" question would indeed nurture the advancement of strategic management. As Chakravarthy and Doz (1992, pp. 9-10) suggest, research in the field must become more relevant to practice. Thus, the approach adopted pretends to be practical in nature and reports on the managerial applications and experiential implications of the matter of study.

In particular, analyzing knowledge management initiatives in manufacturing companies becomes of major interest as it is relevant to further explore how this initiative can help optimize production processes and integrate operational requirements with enterprise-level decision-making processes as well as it can add value to customer in the industry at various stages of value chain such as exploration, inbound logistics, technological operations and outbound logistics.

Considering these previous concerns, the purpose of this research is to study how managers in manufacturing firms approach the challenge of knowledge management in their organizations. Our research methodology is an in-depth case study. The empirical data were collected from Repsol-YPF, an international oil and gas manufacturing company operating in more than 30 countries and leader in Spain and Argentina, in designing and implementing a knowledge management program.

Based on our field investigation, we present the process followed to build a knowledge vision in the company, the first stages of the initiative, the development of new projects, and the lessons learned resulting in the creation of a knowledge management unit, a working model, a strategy, and a set of different projects that were on the basis of the competitive advantage of the organization.

We structure the paper as follows. We begin by discussing the method. We subsequently describe the data and the insights drawn from them. Finally, we tie these insights to the broader agenda of the matter of study and depict the main contributions and limitations of our study as well as suggestions for future research.

Methods
Our research strategy was an in-depth case study. The main reasons that guided this decision is that cases are particularly suitable to answering "how" and "why" questions and are well-suited to generating and building theory in an area where little data or theory exists (Yin, 1984). They also enable researchers to use "controlled opportunism" to respond flexibly to new discoveries made while collecting new data (Eisenhardt, 1989).

Research design
We selected the case study theoretically, and not randomly (Glaser and Strauss, 1967), because the firm studied stands out for the balance between exploration and exploitation. Moreover, it has launched a very ambitious program for the improvement of knowledge in the corporation, in an attempt to improve planning, management and optimization.

Although space prevents our providing "thick descriptions" of the case (McClintock *et al.*, 1979), next we include an overall presentation. Repsol YPF is an international oil

and gas manufacturing company, operating in more than 25 countries and leader in Spain and Argentina. It is one of the ten major private oil companies in the world and the largest private energy company in Latin America in terms of assets.

Repsol YPF's oil and natural gas exploration and production activities focus on profitable, diversified, and sustainable growth with a commitment to safety and the environment. The linchpins of this strategy are increased production and reserves, geographical diversification, operating excellence as a low-cost operator, and profitability by increasing average unitary margins.

The structure of the organization is currently headed by a chairman and chief executive officer, to whom the chief operating officer (COO), seven corporate directors, and the country manager for Argentina report. The COO controls directly eight different business units and an additional corporate direction responsible for all the shared services, while the corporate directors define the lines of action internally and externally, on a world wide scale (Figure 1).

It was counting on the top managers, who launched and supported the initiative of designing and implementing a knowledge management program, that the working team initiated the study on the basis of the conceptual framework of knowledge creation stated by Nonaka and Takeuchi (1995). The building of such a vision, the evolution of the first stages of the initiative and of the new projects generated, together with the lessons learned, resulted in the formation of a knowledge creation unit, the development of a working model, the definition of a strategy, and the implementation of a set of different projects, which can be considered as an important contribution to the basis of the competitive advantage of the organization.

Data sources
As is typical in case studies (Eisenhardt, 1989), we combined different data-collection methods. We collected data through interviews, observations, and secondary sources. The rationale is the same as in hypothesis-testing research. That is, the "triangulation"
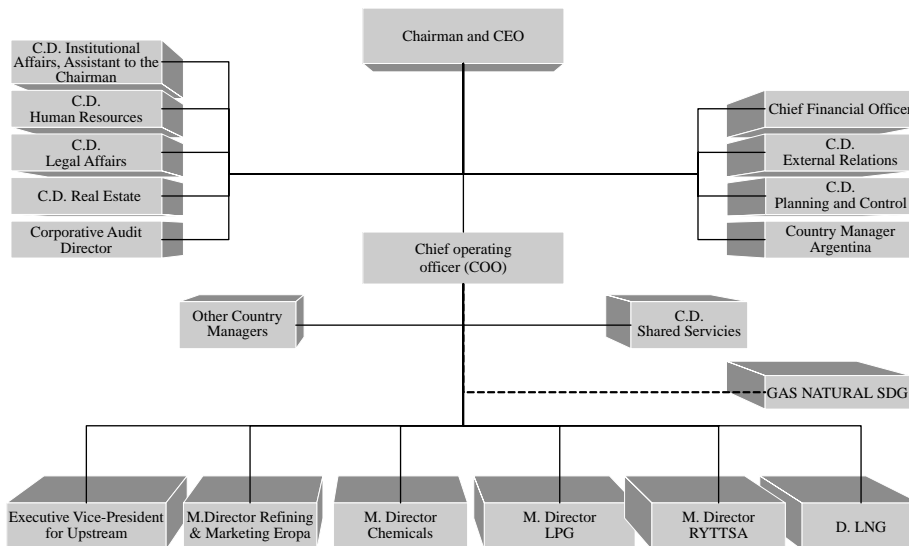

Figure 1.
Repsol-YPF organization

(Webb *et al.*, 1966) made possible by multiple data sources provides stronger substantiation of constructs and hypotheses. Of special note is the combining of qualitative and quantitative evidence. As Yin (1984) points out, case-study research can involve qualitative data only, quantitative data only, or a combination of both, as in our research in an attempt to get synergistic effects.

Interviews. The primary sources were semi-structured interviews with individual respondents, which included managers and employees involved in the definition and development of the knowledge management program. The interviews conducted ranked from 1 to 2 hours. A case-study protocol was developed pursuing reliability in the findings, and a pilot study was carried out in order to refine our data-collection plan with respect to both the content of the data and the procedures followed.

In the first stages of the research, the interviews helped us develop an understanding of the knowledge management program emergence and development in the case studied. In the latter stages, little new information was obtained, and the interviews gradually became a way of increasing the construct validity of the conclusions we were developing. All interviews were recorded and were transcribed immediately afterward. In the transcriptions, we included all data, regardless of its apparent importance in the interview. We then cross-checked facts and ended the transcription notes with our lingering impressions, trying to sharpen them by asking ourselves questions (e.g. What did I learn? How does this interview compare to prior interviews?). We completed the interview notes and impressions within a day of the interview (Yin, 1984).

Observations and secondary sources. The purest form of a longitudinal field study, daily participant observation, was feasible as one of the authors is an executive at the firm studied. This promoted a rich, full understanding of the context and the process from the perspective of someone who has lived through events. Nevertheless, as Leonard-Barton (1990) highlights, the more that the in-depth, real-time longitudinal study approximates a true ethnographic, participant observation strategy, the more the researcher is in danger of losing objectivity – of becoming too involved with the organization, the people and the process. Our attempt to minimize this risk was guided by including the frequent dialogue between the researchers involved (the senior executive mentioned and a strategy professor).

We also used secondary sources to collect background information about the case. Such sources included annual reports; internal documents provided by the interviewees, such as notices of meetings; agendas for meetings; minutes of past meetings; internal newsletters and intranets; and various articles in specialty magazines and newspapers about the situation, evolution and challenges of the airlines companies in general and of the case studied in particular.

Main findings
Next, we describe the experience of Repsol YPF in the development of a vision and the subsequent design and implementation of a knowledge creation program.

Emergence of the initiative
Repsol YPF is aware that future belongs to those who have a vision. The firm's vision is: "To be an international integrated oil and gas company, perceived with admiration, and focused on customer service and value creation."

This short declaration is the guide of the company, showing the organization the path to be taken and how to adapt to continuous change. Repsol YPF wishes to be perceived with admiration in all areas of its activity for giving high-added value, excellence of business management, corporate culture and quality of management inherent to its operations.

To develop this vision, knowledge creation is a must. And as a must it was taken by the corporate directors, who, conscious of how important knowledge creation could be for the successful progress of the activities in the company, decided they should drive the development of a vision.

The first step in this process was the selection of some people from different business units to attend a seminar on the subject. The main questions the company was concerned about at this starting point were the following: what was knowledge creation?; what were the different methodologies and tools for knowledge creation in organizations?; what was the point Repsol YPF was standing at that moment?; if considered interesting, what were the lines of action related to knowledge creation that could be pursued in the company?

As a result of the seminar, some ideas were extracted, that are presented in the following lines. The first finding was that there is not a simple definition for knowledge and its creation in organizations. Knowledge appears as a very broad and complex concept that seems to integrate various dimensions. In particular, when considering knowledge from a constructionist approach (Varela *et al.*, 1991; von Krogh *et al.*, 1994; von Krogh and Roos, 1995; von Krogh, 1998), four conceptual dimensions of knowledge are essentially highlighted: epistemological, ontological, systemic and strategic (Bueno and Salmador, 2003). Stemming from these are the main categories or types of knowledge that Table I summarizes.

Besides, it was found out that there is neither a specific methodology nor special tools for knowledge creation. Companies starting plans in knowledge creation tend to adapt existing technological tools (intranets . . .) or to build their own applications. Yet, there were some knowledge enablers to be considered, such as creating a knowledge intent, developing organizational conversations, developing organizational structure

Conceptual dimensions	Categories or types of knowledge	
Epistemological	Explicit: objective and formulated	
	Tacit: subjective and difficult to articulate and verbalize	Cognitive: linked to emotions and mental models
		Technical: linked to experience
Ontological	Individual: possessed by an individual	
	Social: possessed by a group or organization	
Systemic	Data: input	
	Information: process	
	Knowledge: output	
Strategic	Resource: basically explicit	
	Capability: basically technical tacit	
	Vision: basically cognitive tacit	

Table I.
Conceptual dimensions of knowledge

facilitating knowledge development, managing care relationships, and developing knowledge managers (Ichijo *et al.*, 1998).

Another observation was that, for years, the general trend in companies has been to improve efficiency, to automate manual labor and to reduce redundancy. This tendency has resulted in leaner organization, leading to a decrease of the informal employee communications and, consequently, to less tacit knowledge sharing. All the participants in the seminar agreed: time is a critical factor in knowledge creation.

Several business cases were studied in the seminar, but by the time the analysis was done, most of them were already finished. Any business case is highly dependent on its context, and therefore, specific of the given corporate culture; this fact reduces the probability of success by simply extrapolating the experience to a different system. There is not then a recipe to manage the knowledge creation process. In those cases even under an atmosphere deliberately induced for favouring knowledge creation, there is no guarantee of fail or success.

Promoting mobility of experienced people inside a company is recognized as a knowledge creating way for enabling fluid communication and networking in geographically dispersed teams.

All companies presenting their plans and achievements in knowledge creation (Price Waterhouse Cooper, BSCH, Alcatel, . . .) fully agreed that there are some requirements to make it progress in the organization:

- Top management support is crucial to enable knowledge creation process, and this support means, in practice, that the appropriated resources are allocated and multidisciplinary teams are encouraged.
- Plans in knowledge creation must be aligned with companies' strategies in the long-term, otherwise they would not progress.
- Going from plans to practice may require months of planning and no results that the company should assume.
- Although knowledge creation should be looked at with a global and strategic view, it is better to act locally in the beginning. To start with a selected business case, big enough so that the results can be considered significant, was the way preferred to approach the matter.

Apparently, the seminar did not seem to answer the questions initially formulated. There was a latent absence of "recipes" that could be a guarantee of success. Nevertheless, surprisingly, all the participants from Repsol YPF admitted their heads were full of ideas, further questions, and strong desires to develop a project in the company. This contradiction between what was learned and the feeling that something could be done was a relevant impelling force, which shows what Nonaka and Takeuchi (1995, p. 21) define as a "justified true believe" when referring to knowledge. According to the truth condition, an individual's knowledge of something does not exist unless its proposition is true. The belief condition requires not only that a statement must be true, but also that we must believe that the statement is true. While the truth condition is an objective requirement, the belief condition is a subjective requirement based on individual emotions and perceptions of the environment. The justification condition calls for evidence for proving the truthfulness of knowledge.

The different background and areas of expertise of the people from Repsol YPF attending the seminar – financial, human resources, information systems, engineering, and research and development (R&D) – brought the following multiple approaches and perspectives to the understanding of knowledge and its importance to the firm.

Thus, the pronounced difference between market and book values and the importance of the concept of intellectual capital as a key element to explain this difference (Edvinsson and Malone, 1999; Roos *et al.*, 1997; Sveiby, 1997), captured the attention and interest of the financial responsibles of the company. Traditional accounting does not provide information on firms' intellectual capital. In addition, traditional tools for business management are oriented towards tangible resources. This situation clearly demands the development of new and appropriate tools to measure, report and manage organizational resources based on knowledge (Mouritsen *et al.*, 2001; Petty and Guthrie, 2000). Since mid-1990s, there has been important efforts to develop managerial tools to measure and manage knowledge-based resources. As a result of these efforts, new models of intellectual capital measurement have emerged (Edvinsson, 1997; Sveiby, 1997; Brooking, 1996; CIC (Knowledge Society Research Center), 2003).

On the other hand, the focus of the human resources managers was on the processes of knowledge transfer, including routines for replication and brokering used by companies to copy, transfer, and recombine knowledge resources within the firm (Hansen, 1999; Hargardon and Sutton, 1997; Szulanski, 1996). This is an interesting perspective, since there are people and teams in Repsol YPF that constitute a referent, as they are often contacted for soliciting advice, analysing situations, offering technical solutions, contrasting divergent points of view . . . These experts are well known, but usually this knowledge is restricted to their near environment. The objective in this respect would be double: that the whole organisation may know these people or groups, and to promote the creation of more people and groups that may be considered referents. In this same sense, another interest of the company would be minimizing the lost of tacit knowledge when eventually some people leave the company as well as the leverage of the accumulated tacit knowledge. These objectives imply the measurement and creation of the different processes of maturation of knowledge in teams.

Besides, according to the responsible of information systems, the priority of knowledge creation, would be to improve communication and the processes that allow information transfer. This approach is the one more related with tools, whose importance, though not doubtful, is only complementary with the existence of a vision, a strategy and a culture. As considered from the constructionist approach to knowledge, we need to distinguish between data, information and knowledge. "Books, movies, lectures, papers, computer programs, memos, etc. are data in the environment of the manager – not information. They are simply elements that may be vehicles for potential information" (von Krogh *et al.*, 1994, p. 59). And following von Foerster (1984, p. 193), "information is the process by which knowledge is acquired". Thus, information is dependent on the subject who makes use of it to develop knowledge. In consequence, the subject or agent is at once open and closed. It is open with relation to data of different degrees. The bigger the manifest nature of the data, the easier it will be for the subject to obtain information and, as a result of it, knowledge. On the other hand, the agent is closed with respect to knowledge since for there to be knowledge there must be a system of interpretation. In sum, information systems have an important influence with respect to data, but knowledge depends on the subject or agent.

From an engineer's point of view, to localize "best practices" and to have "lessons learned" are of vital importance, since whether these processes are properly establish or not could make the difference when starting and planning new projects. Knowledge is often characterized as unique, scalable and path dependent, that is, connected to the history (Teece *et al.*, 1997; von Krogh *et al.*, 1994). Yet, while knowledge development is certainly idiosyncratic in its details, it also exhibits common features that are associated with effective processes across firms. These commonalities arise because there is "best practice" that is, there are more and less effective ways of dealing specific challenges (Eisenhardt and Martin, 2000). "Lessons learned" from past experiences in the company, independently whether they were successful or not, are also of great importance. In this line, previous research suggests the role of the pacing of experience and mistakes. Infrequent experience or experience that comes too fast, may lead to an inability to transform experience into meaningful learning (Argote, 1999; Hayward, 1998, 2000; Haleblian and Finkelstein, 1999). This is so either because it can lead to forgetting what was learned previously or because it can overwhelm managers. Mistakes also play a role in the consideration of the "lessons learned". In this respect, small losses, more than major failures or successes, contribute to effective learning (Sitkin, 1992). Small failures provide the greatest motivation to learn; they do not raise defenses that block learning as major failures may bring, and engage managers' attention more efficiently than success does.

Finally, for R&D the creation and diffusion of knowledge are essential, the ultimate reason for this unit being part of a company. In this respect, EIRMA (1999)[1] considers the identification and creation of a company's knowledge assets as a source of competitive advantage and crucial for the success of the firm. Although knowledge creation depends to an extent on the organization, this association identifies seven drivers as the most important:

(1) *Innovation.* To enable an atmosphere for innovation, diverse parts of the organization should interact. By discussing their needs and approaches to problems, working groups will find new solutions. Communities of practice are a good example of the process to favour.

(2) *Organizational learning.* Reviewing past actions help maximise the learning. When properly applied, capturing all the how, what, when, why, where, ... allows a more effective decision to be made in the future. Lessons learned represent this process.

(3) *Globalisation.* Companies are expanding and becoming global, what makes harder to gather the expertise required to solve problems. Virtual team working could be a solution.

(4) *Customer relationships.* The customer perceives the company not as a collection of single parts but as a whole, keen to assist in building a successful future for both. This variable is recognized as a very important source of information for innovation in any firm, that forces to enable the interaction of company's members with customers (OECD, 2000).

(5) *Operational efficiency.* Permanent search of better ways of storing and retrieving the accumulated knowledge is how companies will improve their efficiency. Best practices database is an example.

(6) *Core competencies.* To be conscious of the core competencies necessary and anticipate future needs is crucial to have a real competitive advantage.

(7) *Staff mobility.* Cross fertilization and knowledge creation are enhanced by staff mobility. The loss of an individual should not mean the loss of her or his knowledge to the company.

Although not all the possible perspectives to knowledge creation have been presented, this may well picture the importance of considering them all when developing a shared vision in the company. Repsol YPF had to find a strongpoint to start building the project, where all the different approaches previously mentioned could converge. In this sense, there were interesting theoretical advancements that could indeed contribute to and support this aim. The process of organizational knowledge creation (Nonaka and Takeuchi, 1995), which we summarize next, seemed to meet this requirement, because definitions were general and they could be applied to any subsystem in the organization, with independence of the number of people or their activity. Human resources, information systems, engineering, and R&D identified knowledge conversions as both important and present.

According to Nonaka and Takeuchi (1995) and Nonaka *et al.* (2001), tacit and explicit knowledge interact with each other in a complementary fashion. Tacit knowledge, on the one hand, is knowledge that is hard to formalize and extremely personal. Encompassing intuition, hunches, gut feelings and subjective insights, tacit knowledge is knowing more than can be related in words (Polanyi, 1966). It is entrenched in values, ideals, customs, routines and emotions (Cohen and Bacdayan, 1994; Schön, 1983). Hence, tacit knowledge relates to the "right now," requiring the simultaneous processing that makes it difficult to communicate (Hayek, 1945). Explicit knowledge, on the other hand, is knowledge that can be expressed in verbal and written language, and therefore shared relatively easily. It can be formally presented in data, scientific equations, instruction manuals and other documents. As such, explicit knowledge is easily transferred from individual to individual, group to group, spanning periods of time as well as context (Nonaka *et al.*, 2001). It is this interaction between tacit and explicit knowledge that is called "knowledge conversion." Knowledge conversion is a social process between individuals whereby knowledge is created through the interactions among individuals who possess different types of knowledge. As this conversion process occurs, both tacit and explicit knowledge grow in quality and quantity. The interaction between tacit and explicit knowledge is expressed in four distinct modes of knowledge, introduced to the creation sciences as the SECI process (socialization-externalization-combination-internalization). Each SECI process corresponds, as Byosiere and Luethge (2003) suggest, to tacit knowledge refinement, tacit knowledge translation, explicit knowledge sophistication, and explicit knowledge interpretation, respectively.

Socialization or tacit knowledge refinement is the process of learning tacit knowledge from tacit knowledge through sharing experiences. Thus, tacit knowledge, such as shared mental models and technical skills, is created. An individual can acquire tacit knowledge directly from others through observation, imitation, and practice; being the key to acquire this type of knowledge some form of shared experience. In consequence, it is an informal, associated to emotions, and context-specific acquisition of knowledge by spending time with an individual, living in the same environment and participating in

joint activities. In the business context, tacit knowledge refinement or socialization would be the relation master-apprentice or the organization of activities where participants get to know each other, develop mutual trust and care, and a shared view, such as the use of informal meetings, parties, sports, and dinners.

Externalization or tacit knowledge translation is the process of converting tacit knowledge into explicit knowledge. In addition to continuous dialogue, one way that tacit knowledge can be successfully translated into explicit knowledge is through the sequential application of metaphor, analogy and model (Nonaka *et al.*, 2001). As Nisbet (1969, p. 5) highlights, much of what Michael Polanyi has called "tacit knowledge" is expressible – in so far as it is expressible at all – in metaphor. A metaphor is "two thoughts of different things . . . supported by a single word, or phrase, whose meaning is a resultant of their interaction" (Richards, 1936, p. 93). This connection makes more concrete abstract concepts and uncover new meaning from previous knowledge. Analogy, as Byosiere and Luethge (2003) propose, reduces the differences through the identification of commonalities, using the known to understand the unknown; and once the explicit concepts have been created through the use of metaphor and analogy, models are developed.

Combination or explicit knowledge sophistication is the reconfiguration of explicit knowledge into more complex explicit knowledge. It involves the combination of different bodies of explicit knowledge in a variety of ways, such as through documents, meetings, computerized communication networks, large-scale databases and telephone. Thus, new knowledge can be created by sorting, combining, reorganizing and categorizing explicit knowledge that existed previously, making this knowledge more sophisticated. The organizational view of combination is, for example, when corporate visions, business concepts, or products concepts are broken down and operationalized by the organization.

Internalization or explicit knowledge interpretation is the process of converting explicit knowledge into tacit knowledge. It is closely related to "learning by doing" by means of practice, experimentation and simulation. Internalization can also occur by experiencing other people experiences. This may happen when through books or oral stories, others' experiences may change into a tacit mental model. In an organizational context, the tacit knowledge basis becomes valuable assets that can be shared with others in the firm through the socialization or tacit knowledge refinement process, spiraling a new wave of knowledge creation.

A knowledge creation initiative implies a cultural change, doing things in a different way. Tacit and explicit knowledge are characterized by concrete conducts and modes of conversion. These concepts seem to be a good starting point for the different perspectives given above, because, no matter the disciplines implied in the process, conducts in the knowledge conversion modes are the same.

Development of the initiative
Where to start and how to cover the distance from abstraction to concretion were the two questions to face at the beginning of this process.

Since companies deal with knowledge every day, one starting point could be to determine where the organization stands with respect to the modes of knowledge conversion stated in Nonaka and Takeuchi's (1995) model. As mentioned above, these are general definitions which can be applied to any system, regardless of either the number of people involved or the activity carried out.

The R&D direction was taken as the sample system. The processes which were being developed in this area were analyzed, finding out that activities related to the four modes of conversion defined previously were running. For example, technology watch could be understood as a process of internalization of external explicit knowledge which becomes own tacit knowledge of the organization.

Table II shows the main results of the analysis performed. In particular, the working lines, the tools and process, as well as the situation at the time of the analysis and the future plans are included.

Promoting innovation and cultivating individual creativity is permanently pursuit in a R&D unit. Periodically, as many companies do, brain storming techniques are used to collect new ideas, that emerge directly from the tacit knowledge of the participants in these sessions. For this particular line, the decision was to continue organizing periodical meetings.

Another working line in the tacit to tacit conversion mode was the audit of the scientific methodology used in R&D projects. After a milestone is reached, a group of senior researchers evaluates how the research has been carried out. For example, when a new product formulation is obtained, the audit assures all the chemometrics methods and proper statistics methods were used in the research process. This particular line started in 1996, and by the time this analysis was done, the group realized that the tools to support the process should be improved, establishing the future action line.

Training is a typical internalization mode of conversion of knowledge. Repsol YPF has sponsored annual educational programs for employees for more than 20 years so, as a traditional systematic and periodical activity, no improvement points were found.

Knowledge management activities	Working lines	Tools/process	Situation at the time of analysis/future plans
From tacit to tacit, socialization	Working lines	Brains storming sessions	To be continued: organization of periodical sessions
	Revision of scientific methodology used in R&D projects		To be continued: re-examination of the tools used
From tacit to explicit, externalization	Best practices	Working groups	Lessons learned
	Technical reports, operative procedures	Projects integral management system	To be continued
From explicit to tacit, internalization	Technical training programs	Seminars, congress, informal visits, …	To be continued and exploration of the possibility of internal technical training
	Technology watch		To be extended
From explicit to explicit, combination	Documents management	Documents management	To be continued
	Yellow Pages	Intranet	To be explored
	Library, documentation centre	Library database	Improvement of tools
	Technology map	Database	To be explored

Table II.
Results obtained in R&D from Nonaka and Takeuchi's (1995) knowledge creation. Model application

However, the discussion lead to detect the need of implementing internal courses, since technical knowledge in some matters was not externally available. The subject that made the bell ring was fuel additivation, for which the company has a patented methodology of engine test developed internally that some of the additives manufacturers would like to have for the competitive advantage it represents. Another example are the Racing Gasolines, that have being queens of the circuit for many years. It is not possible to find outside the company this kind of knowledge, so the training of young people must be done in house.

Finally, the group decide to add new lines which reflected some needs the organization had to fulfill and were not considered initially. Examples of these lines are Yellow Pages, technology watch, best practices, and technology map.

On the basis of the results obtained by the R&D direction, and following the guidelines suggested by the corporate director in order to transfer and spread this analysis to the rest of the areas (Figure 2), a working group was formed including members from every direction in Spain and Argentina. The participation of middle managers was of crucial importance. As Nonaka and Takeuchi (1995, p. 127) suggest, "knowledge is created by middle managers, who are often leaders of a team or task force, through a spiral conversion process involving both the top and the front-line employees. The process puts middle managers at the very center of knowledge creation, positioning them at the intersection of the vertical and horizontal flows of information within the company."

The sessions resulted in the construction of an extensive table gathering all the lines actually going on and some of the future needs of the organization. Through the discussion of priorities, the members of the group had each the opportunity of individually express her/his own ideas and beliefs; this is how the development of the shared vision they were looking for started.

Geographical dispersion of the members was the cause for this team to held videoconferences instead of other type of meetings. The consequence of these sessions was the writing of a long list of activities and actions which, once duly classified, showed three main working lines. These working lines had to be undertaken as a priority, since they were the result of a common vision, shared by all the members of the group. These lines, which are developed next, were:

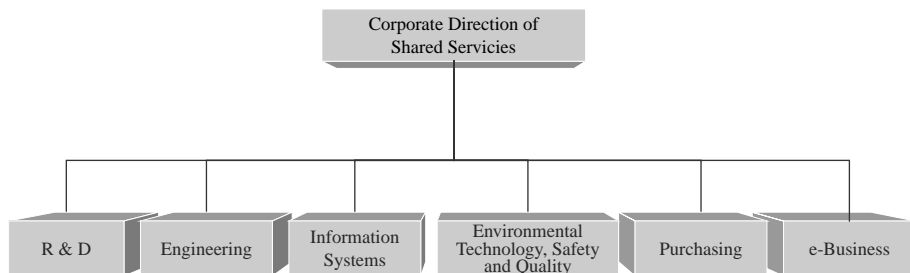(1) Yellow Pages.

(2) Document management.

(3) Lessons learned.

Figure 2.
Corporate direction of shared services organization

Yellow Pages. Either before the starting of a new project or for the evaluation of potential new projects, the project leader should be aware of the related relevant information and knowledge already existent in the organization and know who possesses them. This would help to avoid situations of "reinventing the wheel" and the efforts of the organization could be joined to be more efficiently addressed to one defined direction. Thus, the possibility of undertaking actions with similar objectives in different areas of the company is eliminated.

A skill management system is usually a web-based tool that supports the process. Most international companies operating in several countries have in their intranet all the data necessary to locate their employees (name, telephone extension, department, etc.). However, the information provided is the same included in the organizing chart and usually does not contain the past experiences of the employee, acquired in previous positions inside or outside the firm.

The main goal of the Yellow Pages is to collect such information so that anybody, anywhere within the organization, which is interested in a given subject, may contact fast and easily, by phone or e-mail, with the experts in this subject. Thus, Yellow Pages are not merely a telephone directory.

The human resources unit has an important role to play in this task, assuring the information disclosed of each employee is voluntarily authorized by her or him. This unit also helps defining the competencies and the expertise level for a given capability, in order to establish a scale to compare different degrees of experience.

As a company evolves by its own driving forces, competencies' definitions do not usually correspond to the academic ones. To localize people with expertise in a given subject, there are, at least, three entries that should be provided by the selected informatics' tool: system taxonomy, key words and free text search. The challenge is to establish the process in all the countries where the company is actually operating in order to use it not only to find actual expertise but also to look for the necessary competencies to build the future.

Document management. Organizations produce documents continuously for almost everything, from technical reports to contracts, etc. The knowledge of the members of the organization becomes explicit in many of these documents when issued. Therefore, the systematic management of those documents is a key point to knowledge creation, since it is a means to spread explicit knowledge. There are several commercially available software providing all the functionalities required that could be easily adapted to any firm culture. As in the case of the Yellow Pages, three ways of indexing and recovering documents can be outlined: system taxonomy, keywords and natural language search. The efficiency of these means for retrieving records does not depend on how the software is designed but on how well taxonomy and keywords sets fit the corporate culture, and organizational language.

In this particular business case, although the document management was well solved internally in each of the areas of the corporate direction, the aspect to improve was the documents sharing between these different areas, on the one hand, and with customers, i.e. business units, on the other.

As a way of disseminating explicit knowledge, document management was considered a priority and the goal to homogenize and share documents in the corporate direction was settled.

Lessons learned. The term "lessons learned" expresses the will of harvesting the experience acquired along the development of a given activity, in order to apply this learning in future actions.

This concept is generally used in a "learning society" environment (research and engineering departments) where, despite of the results the projects carried out would provide, the experience which is obtained and gathered along the working process may be valuable for the successful running of new projects.

The aim of this activity is the development of a tool to collect the conclusions of the scientific and technical evaluations of the project, and to transfer this information to those areas of the organization where the accumulated knowledge may be useful.

Considering this background as a basis, working in knowledge creation was approached within the corporate direction in year 2000. From the beginning, the focus of the activity was clearly addressed to practice and to obtain the answers to the questions raised in the organization.

Evolution of the initiative
Once these activities were initiated and the first stages were surpassed, more complex needs of the organization began to emerge. The chain of events had started and processes became more sophisticated.

Work performed during this period concluded with the generation of two additional projects which were included in the knowledge creation program:

(1) thesaurus; and

(2) technology watch.

Thesaurus. In knowledge creation, the communication and use of language are essential, since most of the processes are based on the explicitation of tacit knowledge and its transference through various media. As von Krogh *et al.* (1994) highlight, organizational knowledge both demands and allows for languaging. Because individuals differ in their knowledge and observations, discussions play a role in uncovering differences in distinctions, distinctions at diverse scale, finer or broader distinctions, renamings, etc. For the social system it is by "languaging" that knowledge brings forth a world (Maturana and Varela, 1987; Becker, 1991).

After the introduction of several thousands of documents in the document management system and studying the contents of the old files, the conclusion was devastating: there were lots of documents that could not be retrieved. The assignment of the key words is a subjective tacit process since many different words can be used to refer to the same subject. For instance, while the equivalent terms "gasoline" and "petrol" could be considered the most frequently used to described the fuel for Otto Cycle explosion engine, there are some other synonyms which may also be used, as benzine. Thus, somebody performing a search would wonder how many synonyms are missed and therefore, how many documents are not included in the results set retrieved.

Synonymy is not the only aspect to regard. Preferred orthography, acronyms, different Spanish terms used in each country, are to be considered too.

A thesaurus is a controlled vocabulary consisting of a group of terms whose meaning is characteristic of the group of people using it. The terms of a thesaurus are connected with each other through relationships of hierarchy, associative relations, synonymy, etc. and there exist terms of preferential use and forbidden terms.

The first attempt to solve this problem was the acquisition of a commercialized thesaurus, but none of the market products covered all the activity fields of the company and, as the language has a natural evolution, a thesaurus need continuous updating to prevent terms obsolescence.

Although this could appear as a formidable task, it is nothing when compared to the huge dimension it reaches in the purchase unit. It is possible to limit the technical activity to certain domains, but for the purchase department having a thesaurus means to deal with terms for sanitary aspects, foodstuffs, fabrics, clothes, that is, all the possible domains in ordinary life besides the technical domains.

To minimize the constrains of a traditional thesaurus, computer-based methodologies were used to systematically develop a set of terms covering all the Repsol YPF areas of activities.

The aim of this line of work is thus the automatic generation of a thesaurus characteristic of the activity of the company. In order to generate the specific domain representations, the thesaurus constructed for Repsol YPF is based on domain analysis and the use of CAKE methodology (Grefenstette, 1994; Morato Lara, 1999; Neighbors, 1980; ISO, 1986).

Technology watch. Although innovation is recognized as a competitive advantage, in practice there are few mechanisms to promote and spread it throughout the organizations. Yet, new ideas seem to be often the result of approaching situations from non-conventional points of view. In this respect, Hamel (1998) suggests the consideration of the following aspects to firms:

- New voices, such as young people, newcomers, and those at the geographic periphery of the organization deserve a larger share of voice.

- New conversations. Creating a dialogue about strategy that cuts across all the usual organizational and industry boundaries substantially increases the odds that new strategy insights will emerge.

- New perspectives. New conceptual lenses that allow individuals to reconceive their industry, their company's capabilities, customer needs, and so on substantially aid the process of strategy innovation.

They must search constantly for new lenses that help companies reconceive themselves, their customers, their competitors, and, thereby, their opportunities. Previous research also highlight a common feature of effective knowledge creation processes, that is the explicit linkage between the focal firm and knowledge sources outside the firm (Allen, 1997; Allen *et al.*, 1971; Katz and Tushman, 1981; Henderson and Cockburn, 1994; Powell *et al.*, 1996).

Thus, the knowledge creation process seem to be favoured when each of the members of a working group has the possibility to see what other agents in the firm and in the environment are developing, and information is shared. This mechanism is enhanced as a consequence of a high quality technology watch, which also provides a good perception and knowledge of markets. Technology watch involves explicit knowledge captured that, in a subsequent analysis stage, becomes tacit knowledge of the organization. This is the reason for considering technology watch as a strong support for defining the strategy of the organization, and as a driving force for innovation and for the companies to be more competitive.

The aim of this project is to establish a system for observation and analysis of the environment in order to reduce risk in strategic decision making and to increase the probability of discovering new opportunities.

Repsol YPF was conscious that knowledge could not be managed, in the sense of controlled, but the company could promote the right contexts or "ba" (Nishida, 1992; Nonaka and Konno, 1998) so that knowledge could be converted. While tacit knowledge is embedded in people minds, explicit knowledge is more concrete and permanently sought after under the form of papers, seminars, reports, books, etc. In this case, starting with explicit knowledge management led to initiate new searches of knowledge, acting a chain initiator for the spiral of Knowledge creation.

As a consequence, of the shared vision developed, the following stage was straightforward. In each area of the corporate direction a middle manager was named to be responsible of watching the knowledge creation process and maintain the global view and to coordinate all the new ideas and needs emerging in their correspondent area. These knowledge activists, as defined by Newman (2003), selected the projects leaders and the members of each working group formed. While leaders and group members could change once these projects finish, the activists will continue to spread knowledge, detect new needs, etc.

The organizational structure resultant after the implementation of the knowledge creation program described resembles the hypertext organization as referred by Nonaka and Takeuchi (1995) but knowledge activists are not full time dedicated to knowledge creation functions. The networking established is maintained with the ordinary communication channels in the company (e-mail, videoconference, ...) allowing relationships not related with organization functions or hierarchy.

As mentioned before, the activity of knowledge creation started in 2000. Later, in 2002, after an organizational change in Repsol YPF, a new group joined the corporate direction of shared services: the e-business direction.

This group had been working in knowledge creation before, but with a different initiative. In 1995 they launched a project called data base upstream in the Exploration and Development Business Unit (E&P) in Argentina. The goal was to capture field operation data and the geologists' geophysicists' and engineers' interpretation of them. Avoiding duplicity and data re-entering were not the only expected benefits, since occasionally some data inconsistencies were detected and wanted to be prevented. In E&P data should be captured as close as possible to the place they are created, this means either the well site, the field office or the headquarters, and should be spread on a worldwide basis. The challenge was to have a "unique" concept of data and data sources.

In 1999 the team project began to explore the concepts of going beyond data and information capturing, thinking about ways to put knowledge to work in a more effective manner. It took until 2001 to begin focalized work in this area, although many companies had begun working on this field during the 1990s, not all the experiences were positive and the group did not want to rush spoiling the possibility of exploring this new area and the richness that could be achieved. Sharing knowledge is more complex than simply "throwing" technology at the process. Without reinvent the concept, the group vision was to use others companies experience in their benefit.

Bibliography and other companies' communications showed the group that what has come to be denoted as Communities of Practice (CoP's) were extremely helpful in knowledge sharing.

A CoP is a relatively new organizational structure in a company. It is not based on hierarchies but in common objectives of knowledge creating and sharing, leading to a better knowledge and best practices. A CoP could be defined as a group that comes together voluntarily for a shared purpose, context, interest, set of problems or passion. The members engage repeatedly in activities with other members and are willing to share. In this sense, a task force model is a more flexible, dynamic and participative structure than the hierarchical model, which is more formalized, specialized, centralized and highly dependent on repetitive process, suitable for a large amount of routinary work. Nevertheless, the task force is a temporary solution, and thus, this kind of structure does not easily enable knowledge transfer.

The four basic pillars for the knowledge creation model in this group were:

(1) *Communities of practice.* Non-hierarchical group of professionals/technicians collaborating on regular basis.

(2) *Learning.* Identify what the organization know or not and what is needed to know to meet strategic goals.

(3) *Recognition.* Appropriate process of recognition was considered as if it could lead to a virtuous cycle of knowledge sharing.

(4) *Metrics development.* To establish generic or specific metrics that show the benefit of the process for the company.

In this particular business case, top management support, strategic alignment and global thinking were applied. Today there are 15 CoP's running in Repsol YPF in E&P and downstream business units, R&D direction and human resources.

When e-business direction joined the corporate direction in 2002, the two initiatives were compared in order to evaluate advantages and disadvantages of each, eliminate potential duplication and decide which of the working lines should continue. When the CoPs' were formed, they defined their business objectives and the knowledge they wanted to share. Most of them agreed that expert localization, document management and technology watch were prior processes. The conclusion of this study was that Yellow Pages, document management, and technology watch projects fitted perfectly with the CoP aim of knowledge sharing, since these projects provide the solution for some needs set out. A pilot experience is actually been done with technology watch project and the reservoirs simulation CoP of E&P business unit and the thesaurus become new needs expressed by CoP's as they faced some of the problems of language use mentioned previously. Nowadays, the two initiatives are in progress and being extended to business units.

Conclusions

The purpose of this research was to gather the experience of a manufacturing company in the process of developing a vision in knowledge creation, what has been attempted through the analysis of an in-depth case study. The main conclusions reached can be summarized as follows:

• Nonaka and Takeuchi's (1985) model has provided the necessary framework to ease the convergence of the approaches pointed out by the different groups into a common vision. Through the consequent discussion, this scheme has allowed the path from the abstraction of knowledge creation to the reality of everyday work in companies, where deadlines, deliveries, costs and quality are the usual parameters.

- Work was started by analyzing knowledge creation from a conceptual point of view, identifying the conducts associated to every knowledge conversion mode, what led to the elaboration of a tasks list. The conversion mode which was encountered more often is combination, dealing with explicit to explicit knowledge transfer. While trying to keep in mind a global point of view, the decision was to start working with explicit knowledge tasks, apparently easier to tackle in the first place. However, it was soon found out that these processes had become more sophisticated and that the knowledge spiral had been initiated leading to socialization, that is, tacit to tacit knowledge conversion mode. To illustrate the process undergone, technology watch, document management and communities of practice are some examples.

- To implement the shared vision developed, an organizational structure was required. Thus, the following model was adopted: in each of the areas of the corporate direction, a middle manager was assigned to be responsible for knowledge creation. These managers were selected for their ability as knowledge activists, in charge of maintaining the broad strategic view on knowledge creation, coordinating new ideas and needs emerging on this subject, and selecting the project leaders and the members of each working group formed to make the different activities planned. The project leader and the rest of the members of one working group may leave these knowledge creation tasks once the specific mission they were allocated for has been completed, while knowledge activists should stay longer to nurture the global vision. However, after several years even knowledge activists must rotate, in order the system provides all its potential richness.

- Four years after the launching of this initiative, there is no question in the company about the need of undertaking knowledge creation as a daily activity. Working groups are now harvesting the results of their efforts: the creation of communities of practices and the implementation of projects are actually demanded from different areas of the company since they are already convinced of the benefits of knowledge creation.

- Nowadays, the activity of knowledge creation is firmly established in the company and Repsol YPF faces the future with trust and a bunch of new promising projects.

Because the purpose was practical in nature and reports on the managerial applications and experiential implications of the matter of study, we drew on an in-depth case study. This fact presents some methodological limitations. Yet these limitations raise opportunities for further research because the extent to which the local explanation presented develops into a more general framework will depend on how well it explains the "phenomena" in other settings.

Note

1. EIRMA, the European Industrial Research Management Association, is an independent organization created in 1966 that involves now over 170 companies in 21 countries. The Association's comprehensive programme of activities is design to allow members exchange knowledge and experience for mutual benefit. By sharing best practices in industrial and R&D and innovation members could have a valuable benchmark of their performance.

References

Allen, T. (1977), *Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within the R&D Organization*, MIT Press, Cambridge, MA.

Allen, T.J., Piepmeier, J. and Cooney, S. (1971), *Technology Transfer to Developing Countries: The International Technological Gatekeeper*, MIT Press, Cambridge, MA.

Argote, L. (1999), *Organizational Learning: Creating, Retaining, and Transfering Knowledge*, Kluwer Academic, Boston, MA.

Becker, A. (1991), "A short essay on languaging", in Steier, F. (Ed.), *Research and Reflexivity*, Sage, London, pp. 226-34.

Brooking, A. (1996), *Intellectual Capital*, Thomson Learning, London.

Bueno, E. and Salmador, M.P. (2003), "Knowledge management in the emerging strategic process", *Journal of Knowledge Management*, Vol. 7 No. 3, pp. 1-25.

Byosiere, P. and Luethge, D. (2003), "Realizing vision through envisioning reality: strategic leadership in building knowledge spheres", in Burke, R. and Cooper, C. (Eds), *Leading in Turbulent Times: Managing in the New World of Work*, Blackwell Publishing, Oxford, pp. 243-58.

Chakravarthy, B.S. and Doz, Y. (1992), "Strategy process research: focusing on corporate self-renewal", *Strategic Management Journal*, Vol. 13, pp. 5-14.

CIC (Knowledge Society Research Center) (2003), *The Intellectus Model, Centro de Investigación sobre la Sociedad del Conocimiento*, Universidad Autónoma de Madrid, Madrid.

Cohen, M. and Bacdayan, P. (1994), "Organizational routines are stored as procedural memory: evidence from a laboratory study", *Organization Science*, Vol. 5 No. 4, pp. 554-68.

D'Aveni, R.A. (1994), *Hypercompetition: Managing the Dynamics of Strategic Maneuvering*, The Free Press, New York, NY.

Edvinsson, L. (1997), "Developing intellectual capital at Skandia", *Long Range Planning*, Vol. 30 No. 3, pp. 366-73.

Edvinsson, L. and Malone, M.S. (1999), *El capital intelectual*, Gestión 2000, Barcelona.

EIRMA (1999) Working Groups Reports No. 54, The Management of Corporate Knowledge, EIRMA, Paris.

Eisenhardt, K.M. (1989), "Building theories from case study research", *Academy of Management Review*, Vol. 14 No. 4, pp. 532-50.

Eisenhardt, K. and Martin, L.J. (2000), "Dynamic capabilities: what are they?", *Strategic Management Journal*, Vol. 21, pp. 1105-21.

Galunic, D.C. and Rodan, S. (1998), "Resource recombination in the firm: knowledge structures and the potential for Schumpeterian innovation", *Strategic Management Journal*, Vol. 19 No. 12, pp. 1193-201.

Glaser, B.G. and Strauss, A. (1967), *The Discovery of Grounded Theory: Strategies for Qualitative Research*, Aldine Publishing Co., Chicago, IL.

Grant, R.M. (1996), "Toward a knowledge-based theory of the firm", *Strategic Management Review*, Vol. 17, pp. 109-22.

Grefenstette, G. (1994), *Exploration in Automatic Thesaurus Discovery*, Kluwer Academic Publishers, Boston, MA.

Haleblian, J. and Finkelstein, S. (1999), "The influence of organizational acquisition experience on acquisition performance: a behavioral learning perspective", *Administrative Science Quarterly*, Vol. 44 No. 1, pp. 29-56.

Hamel, G. (1998), "Strategy innovation and the quest for value", *Sloan Management Review*, Vol. 39 No. 2, pp. 78-86.

Hansen, M.T. (1999), "The search-transfer problem: the role of weak ties in sharing knowledge across organization subunits", *Administrative Science Quarterly*, Vol. 42 No. 4, pp. 82-111.

Hargardon, A. and Sutton, R.I. (1997), "Technology brokering and innovation in a product development firm", *Administrative Science Quarterly*, Vol. 42 No. 4, pp. 716-49.

Hayek, F.A. (1945), "The use of knowledge in society", *The American Economic Review*, Vol. 35, pp. 519-30.

Hayward, M.L.A. (1998), "Is learning loopy? Evidence from acquisition experiences", working paper (LRP WP45/1998), London Business School, London.

Hayward, M.L.A. (2000), "Acquirer learning from acquisition experience: evidence from 1985-1995", working paper, London Business School, London.

Henderson, R. and Cockburn, I. (1994), "Measuring competence? Exploring firm effects in pharmaceutical research", *Strategic Management Journal*, Vol. 15, pp. 63-84.

Ichijo, K., von Krogh, G. and Nonaka, I. (1998), "Knowledge enablers", in von Krogh, G., Roos, J. and Kleine, D. (Eds), *Knowing in Firms*, Sage, London.

Illinitch, A.Y., D'Aveni, R.A. and Lewin, A.Y. (1996), "New organizational forms and strategies for managing in hypercompetitive environments", *Organization Science*, Vol. 7 No. 3, pp. 211-20.

ISO (1986), *Guidelines for the Establishment and Development of Monolingual Thesauri: International Standard ISO 2788*, 2nd ed., ISO, Geneva.

Katz, R. and Tushman, M. (1981), "An investigation into the managerial roles and career paths of gatekeepers and project supervisors in a major R&D facility", *R&D Management*, Vol. 11 No. 3, pp. 103-10.

Kotha, S. (1995), "Mass customization: implementing the emerging paradigm for competitive advantage", *Strategic Management Journal*, Vol. 16.

Leonard-Barton, D. (1990), "A dual methodology for case studies: synergistic use of a longitudinal single site with replicated multiple sites", *Organization Science*, Vol. 1 No. 1, pp. 248-66.

Liebeskind, J.P. (1996), "Knowledge, strategy, and the theory of the firm", *Strategic Management Journal*, Vol. 17, pp. 93-107.

McClintock, C., Brannen, D. and Maynard-Moody, S. (1979), "Applying the logic of sample surveys to qualitative case studies: the case cluster method", *Administrative Science Quarterly*, Vol. 24, pp. 612-29.

Maturana, H. and Varela, F.J. (1987), *The Tree of Knowledge*, Shambhala, Boston, MA.

Morato Lara, J. (1999), "Análisis de relaciones cienciométricas y lingüísticas en un entorno automatizado", doctoral dissertation, Universidad Carlos III de Madrid, Madrid.

Mouritsen, J., Larsen, H.T. and Bukh, P.N. (2001), "Understanding intellectual capital statements: designing and communicating knowledge management strategies", in Bontis, N. and Chong, C. (Eds), *World Congress on Intellectual Capital Readings*, Butterworth-Heinemann, London.

Neighbors, J.M. (1980) Software construction using components, Technical Report 160, Department of Information and Computer Sciences, University of California, Irvine, CA.

Newman, V. (2003), *The Knowledge Activist's Handbook: Adventures from the Knowledge Trenches*, Capstone, Oxford.

Nisbet, R.A. (1969), *Social Change and History: Aspects of the Western Theory of Development*, Oxford University Press, London.

Nishida, K. (1992), *Zen no Kenkyuu*, Iwanami Shoten, Tokyo.

Nonaka, I. and Konno, N. (1998), "The concept of 'Ba': building a foundation for knowledge creation", *California Management Review*, Vol. 40 No. 3, pp. 40-54.

Nonaka, I. and Takeuchi, H. (1995), *The Knowledge Creating Company*, Oxford University Press, New York, NY.

Nonaka, I., Byosiere, P. and Toyama, R. (2001), "A theory of organizational knowledge creation: understanding the dynamic process of creating knowledge", in Dierkes, M., Child, J., Nonaka, I. and Antal, A. (Eds), *Handbook of Organizational Learning and Knowledge*, Oxford University Press, Oxford.

OECD (2000), *Science and Technology and Industry Outlook*, OECD Report, OECD, Paris.

Petty, R. and Guthrie, J. (2000), "Intellectual capital literature review, measuring, reporting and management", *Journal of Intellectual Capital*, Vol. 1 No. 2.

Polanyi, M. (1966), *The Tacit Dimension*, Routledge/Kegan Paul, London.

Powell, W., Koput, K. and Smith-Doerr, L. (1996), "Interorganizational collaboration and the locus of innovation", *Administrative Science Quarterly*, Vol. 41 No. 1, pp. 116-45.

Prahalad, C.K. and Hamel, G. (1994), *Competing for the Future*, Harvard Business School Press, Boston, MA.

Richards, I.A. (1936), *The Phylosophy of Rethoric*, Oxford University Press, Oxford.

Roos, J., Roos, G., Dragonetti, N. and Edvinsson, L. (1997), *Intellectual Capital: Navigating in the New Business Landscape*, Macmillan, London.

Schön, D.A. (1983), *The Reflective Practitioner*, Basic Books, New York, NY.

Sitkin, S.B. (1992), "Learning through failure: the strategy of small losses", in Staw, B.M. and Cummings, L.L. (Eds), *Research in Organizational Behavior*, Vol. 14, JAI Press, Greenwich, CT, pp. 231-66.

Spender, J.C. (1996), "Making knowledge the basis of a dynamic theory of the firm", *Strategic Management Journal*, Vol. 17, pp. 45-62.

Sveiby, K.E. (1997), *The New Organizational Wealth*, The Free Press, New York, NY.

Szulanski, G. (1996), "Exploring internal stickiness: impediments to the transfer of best practice within the firm", *Strategic Management Journal*, Vol. 17, pp. 27-43.

Teece, D.J., Pisano, G. and Shuen, A. (1997), "Dynamic capabilities and strategic management", *Strategic Management Journal*, Vol. 18 No. 7, pp. 509-33.

Tsoukas, H. (1996), "The firm as a distributed knowledge system: a constructionist approach", *Strategic Management Journal*, Vol. 17, pp. 11-25.

Varela, F., Thompson, E. and Rosch, E. (1991), *Embodied Mind: Cognitive Science and Human Experience*, MIT Press, Cambridge, MA.

von Foerster, H. (1984), "Principles of self-organization in socio-managerial context", in Ulrich, H. and Probst, G.J.B. (Eds), *Self-organization and Management of Social Systems*, Springer, Berlin, pp. 2-24.

von Krogh, G. (1998), "Care in knowledge creation", *California Management Review, Special Issue on Knowledge and the Firm*, Vol. 40 No. 3, pp. 133-54.

von Krogh, G. and Roos, J. (1995), *Organizational Epistemology*, Macmillan/St Martin's Press, New York, NY.

von Krogh, G., Roos, J. and Slocum, K. (1994), "An essay on corporate epistemology", *Strategic Management Journal*, Vol. 15, pp. 53-71.

Webb, E.J., Campbell, D.T., Schwartz, R.D. and Sechrest, L. (1966), *Unobtrusive Measures: Nonreactive Measures in the Social Sciences*, Rand McNally, Chicago, IL.

Yin, R.K. (1984), *Case Study Research: Design and Methods*, Sage, Newbury Park, CA.

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