The barriers of knowledge generation, storage, distribution and application that impede learning in gas and petroleum companies

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Abstract

Purpose – *This paper aims to find and rank the barriers of the four knowledge management (KM) processes including generation, storage, distribution and application in the gas and petroleum sector.*

Design/methodology/approach – *Reviewing the literature of KM and organizational learning, this paper extracted all of the barriers which impede KM processes. Then it designed a questionnaire for validating, ranking and categorizing barriers. Totally, 190 completed questionnaires were gathered from 26 gas and petroleum companies in Iran. Some statistical tests such as* T*, Friedman, Kruskal–Wallis and Mann–Whitney were used for analyzing data.*

Findings – *Findings reviewed the current literature of KM barriers, validated and ranked the barriers of knowledge generation, storage, distribution and application separately. The importance of knowledge generation and knowledge application barriers were significantly different between gas and petroleum companies. Hence they were disjointedly ranked for gas and petroleum. Finally, KM barriers were ranked according to their contribution to KM processes and the average mean of their importance in KM processes.*

Practical implications – *From the practical point of view, this paper suggests managers of gas and petroleum companies to emphasize solving high-priority barriers according to the KM process which they are focused on. Furthermore, the study provides a checklist that can be used as an assessment tool for evaluating KM processes considering barriers.*

Originality/value – *This paper finds the importance of each barrier for each of the four KM processes and ranks the "critical barriers" according to their contribution to four KM processes in the gas and petroleum sector.*

Keywords *Knowledge sharing, Knowledge management, Knowledge management processes, Organizational learning, Gas and petroleum, Knowledge management barriers*

Paper type *Research paper*

1. Introduction

Knowledge management (KM) has received considerable attention in the energy sector, including gas, oil and petroleum sectors (Brown *et al.*, 1997; Phillips and Vollmer, 2000; Behounek and Martinez, 2002; Bargach *et al.*, 2001), because of its impact on their performance (Mesler, 2002; Minyard, 2003; Troxler and Lauche, 2003; Salmador Sánchez and Palacios, 2008). For example, Halliburton (Edwards and Kidd, 2003; Behounek and Martinez, 2002; Ash, 2005), Schlumberger (Smith and Farquhar, 2000; Etkind *et al.*, 2003) and Petroleos de Venezuela (Quintero and Ungredda, 2003) have implemented some KM initiatives such as virtual seminars (Nelson, 1997), communities of practice (CoP) (Edwards and Kidd, 2003), etc., and Iranian oil gas and petroleum companies have welcomed KM initiatives such as developing KM strategy, implementing KM systems, creating knowledge tree and knowledge maps, designing knowledge-based reward systems, documenting experiences, fostering knowledge-sharing culture, building communities of practice (CoPs), measuring KM maturity, etc.

"The importance of knowledge generation and knowledge application barriers were significantly different between gas and petroleum companies."

On the other hand, the capability to create and apply new knowledge seems to be a source of competitive advantage, which is hard to imitate (Nonaka, 1991; Spender, 1996; Zollo and Winter, 2002; Crossan and Berdrow, 2003), and organizational learning (OL) is a means to develop such capabilities. Some researchers emphasized on the importance of access, sharing and creation of knowledge as a part of an organization's ability to learn and be innovative (Krogh *et al.*, 2000; Davenport, 2005). For example, as stated by Argote (1999), "learning involves the processes through which members share, generate, evaluate, and combine knowledge" (Vera and Crossan, 2001). As OL and KM include cognitive and behavioral aspects of learning and knowledge, studying knowledge-associated processes instead of knowledge assets is a good opportunity to take advantage of the insights of both concepts (Vera and Crossan, 2001). There exists some academic and practitioner literature relating to the barriers that most likely hinder or impede OL (Szulanski, 1996; Hiregoudar and Kotabagi, 2007; Schilling and Kluge, 2009) Also, there are a wide variety of papers that focus on knowledge-sharing or knowledge-creation barriers (Chinying Lang, 2001; Riege, 2005; Ardichvili *et al.*, 2003; Yih-Tong Sun and Scott, 2005; Telvin Goh and Hooper, 2009; Zapata Cantu *et al.*, 2009).

Now, it is a good time to first categorize and rank the barriers separately for the more important knowledge processes and then find the most effectual barriers, which affect more than one KM process in the gas and petroleum sector. The results motivate managers to place greater emphasis on solving those high-priority barriers, which are more important according to the KM processes they are focused on in their organizations. Although there is a rich literature about KM barriers, the question of how these barriers impress the distinct phases of the knowledge processes remains unanswered. This paper aims to contribute in this area. We define knowledge process barriers as factors that impede generation, storage, distribution or application of knowledge, which in turn leads to hinder OL. Based on the process view of learning literature, this paper infers that an organization should be capable of managing knowledge processes to promote learning. Hence, the goal of this research is to identify, integrate and categorize barriers, which impede OL through affecting knowledge processes in oil and gas companies, so that it takes advantage of integrating the literature of OL and KM.

To tackle this research challenge, the authors tried to comprehensively study the literature of OL and KM for extracting barriers. Then, we carried out an empirical study to:

- identify the most important KM barriers in gas and petroleum companies;
- categorize the barriers according to the KM processes;
- find the importance of each barrier for each of the four KM processes; and
- rank the "critical barriers" according to their contribution to the four KM processes.

Finally, the study provides a checklist as an assessment tool for evaluating KM processes considering barriers and their importance. The results help managers to improve their KM activities. This paper contributes to theory validation in KM by investigating the effect and rank of the barriers in each KM process along with their differences between gas and petroleum companies.

Iran has the second-largest reserves of gas and the third-largest reserves of oil and is the second-largest chemical producer in the world. It is the world's fourth-largest oil producer

and is Organization of the Petroleum Exporting Countries (OPEC's) second-largest producer and is a major power in the international market. So, this paper might be of value due to the unique characteristics of the Iranian gas and petroleum companies, which support the results.

The paper is structured as follows. In Section 2, the authors will review the theoretical background. Next, we will discuss about the various models for knowledge processes and OL processes and choose one that best fits the goal of this paper. Section 3 briefly introduces the research method that has been followed. Then, the barriers that lead to shortage in KM are explained. After that, the results of the empirical research will be presented and discussed. Finally, conclusions will be drawn.

2. Theoretical background

There are different approaches for the OL concept, which are described in article reviews such as Nicolini and Meznar (1995), Miner and Mezias (1996), Edmondson and Moingeon (1996), Easterby-Smith (1997), Crossan *et al.* (1999), Pawlowsky (2001), Ortenblad (2002), Kluge and Schilling (2003), Friedman *et al.* (2005), Lawrence *et al.* (2005) and Shipton (2006). For example, Shipton (2006) presented a comparative framework to categorize the literature according to its prescriptive/explanatory bias. The prescriptive literature takes the positive relationship between OL and performance as a premise, the explanatory literature "is concerned with understanding how organizational learning happens, and identifying barriers and inhibiting factors"; and "in line with the level of analysis, examining whether there is a focus on the organization as a whole, or instead upon individuals and their work communities". This theme brings together work examining whether and how individuals can transfer their learning into the organizational domain, along with studies exploring how organizations shape learning activity and knowledge construction (Shipton, 2006). About the level of analysis, it is necessary to point out that some authors argued that learning takes place in three levels: individual, group and OL. They distinguish between learning in a group and learning in an organization (Crossan *et al.*, 1999; Gomez *et al.*, 2005).

According to the normative literature, the authors assume OL as a positive phenomenon and then as the explanatory literature tries to find barriers, which impede learning at individual, group or organizational level. Two kinds of learning are well-known in the literature, which are single-loop or lower-level learning and double-loop or higher-level learning (Argyris and Schön, 1996; Ortenblad, 2004), or generative learning (Senge, 2006) or radical learning (Miner and Mezias, 1996). The former is about continuous improvement in the ways of doing things and the latter is related to the capacity to question these courses of action (Ortenblad, 2004). Moreover, "There is a dual nature of learning for OL in different theoretical conceptions which are learning as a process (perceiving and processing information, i.e. experience) and learning as a result (modified knowledge or skill)" (Schilling and Kluge, 2009).

Different processes are defined in the process view of learning, for example intuiting, interpreting, integrating and institutionalizing in the knowledge/information acquisition, distribution, interpretation and organizational memory (4I model) (Huber, 1991); or socialization, externalization, combination and internalization (SECI model) (Nonaka and Takeuchi, 1995); or acquisition, transfer and integration (Gomez *et al.*, 2005). All kinds of aforementioned processes have different natures. Some of them explore for new learning and others just exploit what has already been learned. The first one that deals with new possibilities is called exploration (feedforward process of learning), and the second one is associated with well-defined and routine part of the business, which is known as exploitation (feedback processes of learning) (March, 1991; Crossan and Berdrow, 2003). This paper tries to help managers by identifying barriers related to those knowledge processes even exploring or exploiting, which impede single-loop and/or double-loop learning in the organization that may be associated to individual, group or organizational level. There is a strong link between learning processes and knowledge processes so that learning can be defined in terms of the processes of knowledge

creation, transfer, etc. (Vera and Crossan *et al.*, 2001). This paper attempts to categorize learning barriers based on the processes of KM including generation, storage, distribution and application. Persuading this goal, in the next section, the authors first review some models from the literature of OL and KM to choose a knowledge process model that best fits the aim of this paper.

2.1 KM process models

KM focuses on knowledge processes that support organizational processes such as innovation, individual learning, collective learning and collaborative decision-making (King, 2009). This paper compares some of the well-known KM process models to constitute a justified framework for categorizing the barriers of knowledge processes. Process-oriented KM models analyze the variables affecting development, dissemination, modification and use of knowledge processes (Gebert *et al.*, 2003); examples of process-oriented KM models include Wiig (1995), Probst *et al.* (2000), McElroy (2002), etc. Up to eight processes are introduced for knowledge in several theoretical models. Some of them are very similar and only their terminology is different, and so can be synthesized. Table I presents an overview of some of the most famous KM process models and their components.

Mertins *et al.* (2003) reviewed a variety of KM processes, presented by previous authors such as Davenport and Prusak (1998) and Probst *et al.* (1998), and carried out a survey to find the importance of different KM activities including generation of new knowledge, storing and preserving knowledge, distributing knowledge, applying knowledge, identifying knowledge, formulating knowledge goals and other core activities. The consequence revealed that the four KM processes, including "apply", "distribute", "generation" and "storage", were the most significant from the top European company's point of view. Due to Mertins *et al.*'s result, this paper tries to find those barriers which impede learning through destructive effect on the four most important KM processes, which are defined as follows:

1. *Generation* (synonyms of creation, production and development): Knowledge creation means generating or discovering new knowledge through R&D, experimentation, lessons learned, creative thinking and innovation, which is the most advanced stage of KM (Rastogi, 2000). Probst *et al.* (2000) named this process as *development* and suggested that it is a building block, which complements knowledge acquisition and includes all management efforts consciously aimed at producing capabilities. McElroy used the term *production* to refer to this process, as he stated that knowledge production is associated with the creation of new organizational knowledge.
2. *Storage* (synonyms of preservation): It means "storing existing, acquired, and created knowledge in properly indexed and inter-linked knowledge repositories" (Rastogi, 2000). Probst *et al.* (2000) used *preservation* for this meaning and defined it as the process of selective retention of information, documents and experience required by management. Knowledge stocking is seen as the repository of knowledge in the firm, which is the result of the knowledge assets accumulation over time (Paarup Nielsen, 2006).
3. *Distribution* (synonyms of sharing, integration, dissemination, and transfer): Distribution means sharing and spreading the knowledge that already exists within the organization

Table I KM process models

Author	*Knowledge processes*
Nonaka and Takeuchi, 1995	Socialization, externalization, combination, internalization
Rastogi, 2000	Identification, mapping, capturing, acquiring, storing, sharing, applying, creating
Probst *et al.*, 2000	Identification, acquisition, development, distribution, utilization, preservation
McElroy, 2002	Production, integration
Alavi and Leidner, 2001	Creation, storage and retrieval, transfer/distribution and application
Mishra, 2009	Capture and/or creation, sharing and dissemination, acquisition and application
Mertins *et al.*, 2003	Generation, storage, distribute, apply

(Probst *et al.*, 2000). Knowledge-sharing process consists of transfer and diffusion of best practices (Rastogi, 2000), which occurs between a knowledge source and a recipient unit (Szulanski, 1996). Some activities such as knowledge broadcasting, searching, teaching, sharing and other social activities allow the sharing and distribution of knowledge and form knowledge integration (McElroy, 2002).

4. *Application* (synonyms of utilization): Knowledge application means "retrieving and using knowledge in support of decisions, actions, problem-solving, automating routine work, providing job aids and training" (Rastogi, 2000). Another synonym word is *utilization*, as defined by Probst *et al.*, which consists of carrying out some activities to make sure that the existing knowledge is applied productively (Probst *et al.*, 2000).

3. Research method

A well-structured literature review can provide an excellent foundation for further research in new or very narrow topics (Seuring and Müller, 2008) and can help in identifying conceptual content and developing theories (Meredith, 1993; Seuring and Müller, 2008). First, by reviewing the literature of KM process models and comparing them, the authors selected Mertin *et al.*'s KM process model as a framework for categorizing barriers, which influence KM processes. Second, all the barriers mentioned in the previous research works for OL or KM processes were extracted and the initial version of the barriers was made. Third, the authors discussed about the concept of each barrier and removed the repetitive barriers even mentioned by various names. The authors repeated this step in three rounds until the final list of the barriers was achieved. Fourth, the findings were classified into five groups including people-related barriers, technology-related barriers, organization-related barriers, environment-related barriers and knowledge characteristic-related barriers by comparing and combining the various classifications of KM barriers in the existing literature. Fifth, a questionnaire was designed with 44 items for barriers, without any prejudgment about the KM processes that each barrier may affect, and respondents of 26 Iranian gas and petroleum companies were asked about the degree (from 1 to 5) of effect they believe each barrier has on each of the four KM processes. So, there were four columns in front of each barrier and the respondents elected a number from 1 to 5 in each column for the relevant barrier.

In total, 300 questionnaires were mailed for 45 gas companies and 400 questionnaires for 18 petroleum companies along with a formal letter from the National Iranian Gas Company (NIGC) and the National Iranian Petrochemical Company (NPC). In the letter, the authors asked the respondents to be volunteer representative staff with academic grade equal to or higher than BSc and preferably familiar with KM. Finally, the authors received 58 completed questionnaires from 11 departments of gas companies and 132 completed questionnaires from 13 departments of petroleum companies (total response rate was 27 per cent). Data were analyzed by means of the statistical methods (mean, variance and *t*-test), which run in SPSS 13 for validating and ranking important barriers of each KM process. The missing values were ignored and the knowledge process barriers were ranked according to their respective mean.

4. Barriers in managing knowledge processes

There exist many barriers along with the processes of KM, which turn the management of knowledge into a very challenging task (Thoben *et al.*, 2002). Although the academic and practitioner literature of barriers relating to both learning processes (such as intuition, interpreting, integration and institution) and KM processes (such as creation and sharing/distribution) is widespread and diverse, there is lack of a holistic perspective at these barriers from the point of view of KM processes. Furthermore, there is a close interrelationship between OL processes and KM processes, for example "intuition" process of OL, which deals with recognition of the patterns and/or possibilities inherent in a personal stream of experience (Crossan *et al.*, 1999), is very similar to knowledge-creation process. Therefore, there is a good opportunity to take advantage of the integration of the barriers

previously expressed for OL processes and KM processes separately. Some researchers just focused on one KM process, especially on knowledge sharing or distribution (Ardichvili *et al.*, 2003; Yih-Tong Sun and Scott, 2005; Telvin Goh and Hooper, 2009; Zapata Cantu *et al.*, 2009). For example, Zapata Cantu *et al.* examined the significant variables of generation and transfer of knowledge in information technology-related small and medium enterprises and demonstrated the relationship between knowledge-generation and knowledge-sharing processes (Zapata Cantu *et al.*, 2009).

Moreover, there are various classifications for barriers. Barson *et al.* (2000) looked at the barriers of successful knowledge transfer by categorizing them into three groups including technological, organizational and people-related barriers. Based on the Barson *et al.* (2000) classification of barriers (technology, organization and people), McLaughlin *et al.* (2008) classified barriers of the knowledge creation and sharing according to SECI model (Nonaka and Takeuchi, 1995). They developed a list of 25 main barriers in four categories (people, technological, organizational and cross-category barriers) for knowledge creation and transfer and used them for assessing the main barriers to knowledge creation and transfer across a core IBM supply chain process. Schilling and Kluge classified OL barriers in three types of actional-personal, organizational-structural and societal-environmental (Schilling and Kluge, 2009), and argued about the barriers of OL processes including intuiting, interpreting, integrating and institutionalizing. As they focused on individual and organizational behavior that hinders OL, they did not include some parts of the KM aspects such as knowledge storage (Schilling and Kluge, 2009). Rego *et al.* (2009) surveyed the barriers of knowledge gathering, creation and dissemination in university research centers. They classified these barriers into three types including individual, socio-organizational processes and technology. In this paper, the authors reviewed this expanded literature with the aim of identification of the barriers impeding learning by affecting KM processes, without any prejudgment about the KM processes that each barrier impacts on it. A survey was carried out with the aim of categorizing learning barriers based on Mertins *et al.*'s (2003) four knowledge processes (generation, distribution, storage and application), which is explained in the previous section, besides validating the barriers themselves. In the following, the barriers will be reviewed. When compared with previous research works, our study is more extensive because it identifies barriers by reviewing both OL and KM literature in a more precise classification considering barriers related to people, technology, organization, environment and characteristics of the knowledge. Finally, the main contribution is categorizing them according to the four KM processes instead of just one or two processes and finding the more important barriers.

4.1 Barriers related to people

The emphasis on the importance that the individual plays in the KM processes is a widely supported view. "The employee should see knowledge management, or to be precise the active application, distribution and cultivation of knowledge within the organization as a whole, as a fundamental part of their personal success and satisfaction" (McLaughlin *et al.*, 2008). People barriers include basic psychological phenomena, which occur as the individual perceives his/her environment, such as lack of motivation, fear of disadvantages, etc., and various barriers related to people are expressed as follows:

- *Lack of slack times and heavy workload*: If an organization is to operate knowledge creation and sharing, then people should have the required time available (McLaughlin *et al.*, 2008) to use KM methods and tools and train people (Pawar *et al.*, 2001). They should have enough time to create contacts and promote relationships with internal and external knowledge sources (Riege, 2005).
- *Fear of loss of ownership and control of knowledge property and individual competitive edges/professional identity*: People know that their knowledge is a source of their power and think that if they tell it to others, their clout in the organization will diminish (Yih-Tong Sun and Scott, 2005). They fear a loss of ownership, an idea rubbery, a position of privilege and superiority over their intellectual property, and individual

competitive edge (Szulanski, 1996; Thoben *et al.*, 2002; Pawar *et al.*, 2001; Riege, 2005; Schilling and Kluge, 2009). McLaughlin *et al.* (2008) referred this barrier as self-interest (expose knowledge to competition). This means holding back on knowledge sharing with co-partners because of a belief that the knowledge will filter to competitors. The fear of the loss of ownership is not necessarily a purely individual problem, but rather can be related to the specific organizational culture (Schilling and Kluge, 2009), which will be described in organization-related barriers.

- *Trust/reliability of knowledge source or recipient*: This means the individual should trust the source or recipient of the knowledge to use it correctly (McLaughlin *et al.*, 2008). In other words, the individual should agree with some of the decisions that the recipient may take based on the received knowledge and be sure that he/she uses it suitably and does not create problem by misusing it (Yih-Tong su and Scott, 2005). Also, the trustworthiness of the source unit influences on the behavior of the recipient. If the source is seen as trustworthy and knowledgeable, then knowledge will be transferred more easily (Szulanski, 1996; Pawar *et al.*, 2001). Trust helps to decrease cultural barriers (McCann and Buckner, 2004). Tong and Mitra (2009) studied the effects of trust on Chinese culture that influences KM practices. However, an organization can enhance trust, for example, by facilitating face-to-face communication (Schilling and Kluge, 2009; Hauk, 2006), but trust is naturally a factor more related to a person rather than an organization.
- *Lack of retentive capacity*: "A transfer of knowledge is effective only when the transferred knowledge is retained" (Szulanski, 1996). Retentive capacity refers to the ability of the recipient to routine or to institutionalize the use of new knowledge (McLaughlin *et al.*, 2008; Schilling and Kluge, 2009). Lack of such a capability leads to initial difficulties during the integration of received knowledge and may be a reason for discontinuing usage of that knowledge (Szulanski, 1996).
- *Lack of absorptive capacity*: Absorptive capacity refers to the ability of the recipient to exploit outside the source of knowledge, which is largely a function of his/her preexisting stock of knowledge and manifested in his/her ability to value, assimilate and apply new knowledge successfully to commercial ends (Szulanski, 1996). Lack of absorptive capacity in groups negatively affects the interpretation process of OL (Schilling and Kluge, 2009). "A lack of knowledge, skills and abilities is an important obstacle to closing the learning cycle from innovation to practice" (Schilling and Kluge, 2009).
- *Poor communication and interpersonal skills (Riege, 2005)*: This involves the skills of staff in effectively expressing a thought or information (Yih-Tong Sun and Scott, 2005). The political and social skills of the persons who generate and/or champion an idea or new knowledge have great impact on its acceptance by co-workers or groups (Schilling and Kluge, 2009). "Stories must be told, revised, and retold in ways that capture the imaginations of co-workers, affirm their identities, and inspire collective action" (Lawrence *et al.*, 2005, p. 183). A different language is a barrier, which affects communication among people and is specially highlighted in international companies (Riege, 2005).
- *High level of stress and fear of disadvantage/risk*: Riege pointed that people show apprehension or fear toward sharing their knowledge because it may reduce or jeopardize their job security (Riege, 2005). People are afraid that their knowledge may be inadequate or unimpressive and display their lack of knowledge (Yih-Tong Su and Scott, 2005). They have a fear of giving not clearly defined ideas ("soft ideas"), which may be regarded as their weakness (Pawar *et al.*, 2001; Thoben *et al.*, 2002; Ardichvili *et al.*, 2003). They "avoid being associated with concrete instances of failure, as they otherwise risk being stigmatized as incompetent and cut off from valued organizational rewards" (Schilling and Kluge, 2009). McLaughlin *et al.* (2008) called this barrier as *risk*, which means fear of penalty or losing profit. Risk will affect knowledge sharing and is related to both trust and proprietary knowledge barrier (an organization-related barrier) (McLaughlin *et al.*, 2008).

- *Lack of motivation*: People may perceive knowledge sharing as intrusive and extra work and hence do not support it (Riege, 2005). In a knowledge-sharing relationship, motivation of both the innovator to pursue his/her idea (Szulanski, 1996; Hiregoudar and Kotabagi, 2007; McLaughlin *et al.*, 2008; Schilling and Kluge, 2009) and the recipient to accept the new knowledge ("not-invented here" syndrome) is important. Obviously, the motivation could be either intrinsic or extrinsic. While the nature of intrinsic motivation is intangible, extrinsic motivation could be enhanced through rewarding and recognizing employees with tangible form for their knowledge-sharing efforts (Singh and Kant, 2008); hence, a lack of reward is another barrier that impacts motivation and will be described as an organization-related barrier.
- *Lack of top management support*: The managers have an important role in developing a good condition in an enterprise by establishing technical infrastructure, reserving time for meetings, motivating staff and to ensure a suitable atmosphere inside the company and also with business partners (Hauk, 2006). If an organization's top management does not support an idea, it will be most difficult to achieve collective action based or focused on the innovation (Schilling and Kluge, 2009). Also, lack of leadership and managerial direction clearly affects communicating the benefits and values of knowledge sharing (Riege, 2005). "Not only top management, but also middle and lower management have to play their part in institutionalizing innovations" (Schilling and Kluge, 2009).
- *Divergent aspirations of teams*: Innovation as a threat: Individuals and teams may have their own interest and aspirations, which are not compatible with the new ideas they are supposed to implement (Schilling and Kluge, 2009). They want to continue in the comfort zone they have created (Yih-Tong Sun and Scott, 2005). In this case, the innovation would be regarded as a threat, and counteracted (Schilling and Kluge, 2009). Individual's interest is rooted in the context of the organization they operate in such an organizational structure (Yih-Tong Sun and Scott, 2005). For example, decentralization or silo thinking, which will be explained later as an organizational barrier, is likely to bring difficulties in implementing innovative ideas and keeping them alive. Another contextual example that reduces the openness of employees to new ideas is a negative attitude toward changes (cynicism toward change) or cynicism toward the organization as a whole (Schilling and Kluge, 2009).
- *Different individual characteristics*: Sometimes, people show little or no knowledge-sharing activities due to different levels of education, different languages (Chinying Lang, 2001; Thoben *et al.*, 2002; Pawar *et al.*, 2001), differences in experience levels or different gender and other personal characteristics (Riege, 2005).

4.2 Barriers related to technology

Information technology is a primary enabler for KM (BenMoussa, 2009), as it provides a strong platform to KM and enhances its impact in an organization (Singh and Kant, 2008) by making the ability to acquire, retain and share knowledge (McCann and Buckner, 2004). Effective KM is impossible without effective information systems and technologies (IS/IT) such as business intelligence, knowledge base, collaboration, portals, customer management systems, data mining and workflow (Singh and Kant, 2008). In the following, barriers related to technology are described.

- *Lack of available technology:* This barrier relates to the lack of technical support (internal or external) and immediate maintenance of integrated technology to support KM requirement (Riege, 2005; McLaughlin *et al.*, 2008). Without technology, it is difficult to collect and analyze data as well as generate and distribute knowledge/information (Yih-Tong Sun and Scott, 2005). Hence, establishing a system to support the flow of knowledge helps in the maximization of the value of knowledge (Ajmal *et al.*, 2010). Schilling and Kluge (2009) explained this barrier in terms of technical/structural difficulties of storing implicit knowledge, because even if technology is available but

inappropriate, it can be expected to result in resistance on the part of the employees; in fact, integrated IT systems and tools should support people's work processes and actual communication flows (Riege, 2005). Lack of money can be a cause of developing technology.

- *Trash information:* "Mountains of information captured by very expensive, often inflexible IS/IT initiatives too frequently make it difficult to identify and measure what really drives organization performance" (BenMoussa, 2009).
- *Legacy systems:* "A legacy system can be described as any or all of the following: large, old, heavily modified, difficult to maintain, and old fashioned" (Brooke and Ramage, 2001). However, legacy systems are still necessary due to the specialized nature of their operations (Kulonda *et al.*, 2003). Legacy systems between departments (business units) impact on knowledge generation and distribution (Thoben *et al.*, 2002; McLaughlin *et al.*, 2008). Connecting the systems of multiple departments, especially when there is lack of compatibility (Riege, 2007) and no common standard approach to IT deployment, makes it difficult to solve an efficient knowledge transfer system (McLaughlin *et al.*, 2008).
- *Useless technology:* Sometimes, people show a reluctance to use the integrated IT systems and tools (Riege, 2005). This may be due to the lack of familiarity and experience with systems and tools. They may have fear of complexity of new applications (Riege, 2005). So, this barrier can be suggested to be an effect of lack of absorptive capacity, which is a people-related barrier. Also, this barrier may occur as a result of significant technological problem in the application or due to low level of user-friendly systems (Riege, 2005).
- *Unrealistic expectations of technology:* People set unrealistic expectations as to what technology can do or cannot do. Kennedy *et al.* (2008) discussed about the disappointing history of KM (as a system that identifies, stores and distributes a firm's institutional knowledge) in offering much promise to lawyers at law companies and argued that this occurred because lawyers had unrealistic expectations about what KM tools can deliver. Benbya (2008) mentioned some unrealistic expectations for IT-based solutions such as: "thinking that by relying on a specific technology, KM can capture best practices, success stories, and lessons learned that could then be reapplied by the others". In fact, they often emphasize on the technology "rather than on how it should operate, what problem it is supposed to address, and how it will integrate with the overarching technology strategy".

4.3 Barriers related to processes/organization

- *Lack of fitness between knowledge and important organizational goals*: "The less an idea is coupled with important goals or costly errors, the lower is its acceptance by other team members" (Schilling and Kluge, 2009). The goals should be set and the derivers for the KM initiative should be understood; also, what knowledge is critical to keep and what should not be kept should be clear (BenMoussa, 2009); otherwise, it is relatively difficult to learn from failures and performance gaps. Lack of measurement system and unclear criteria of success impede learning from previous failure and performance gaps because they are not clearly identified (Schilling and Kluge, 2009).
- *Poor targeting of knowledge*: Although IS/IT captures or "codifies" information, information is not knowledge. "Information must be accessible and relevant to a moment and situation for it to support meaningful knowledge generation and application" (BenMoussa, 2009). Scarborough *et al.* (1999) pointed out that "information needs to be targeted if it is to serve knowledge" (cited in Barson *et al.*, 2000). For a KM system to function effectively, it is required to clearly identify the areas in which it will be used (Barson *et al.*, 2000) and what information is needed to be targeted to generate what knowledge (McLaughlin *et al.*, 2008). "Don't try to boil the ocean" (Lank, 1997 cited in Barson *et al.*, 2000).

- *Distance/arduous relationship*: Geographical distance is likely to impact knowledge sharing. Physical work environment and layout of work areas in the organization can restrict knowledge transferring among people (Riege, 2005; Rego *et al.*, 2009; Wendling *et al.*, 2013). "According to Nonaka and Takeuchi (1995), the most efficient means of transferring knowledge is through face-to-face communications. However, the distributed nature of today's organization may make this difficult to do" (McLaughlin *et al.*, 2008). Szulanski (1996) referred to this barrier as *arduous relationship*, which means lack of easy communication between knowledge source and recipient, which affects the success of knowledge transfer, especially when it has a tacit component (Szulanski, 1996).
- *Leadership styles*: Poor leadership and managerial direction hinder KM (Riege, 2005; Rosen *et al.*, 2007). Top-down leadership styles lead to poor coordination across functions, and laissez-faire leadership styles lead to poor vertical communication; so, they both hinder knowledge sharing, which occurs in integration process of learning (Schilling and Kluge, 2009).
- *Culture*: A company's culture may not support sharing and reuse of knowledge (De Long and Fahey, 2000; McLaughlin *et al.*, 2008; Ajmal *et al.*, 2010). Organizational blame culture punishes employees for deviating from norms or regulations and thereby generates a lack of psychological safety, hopelessness and organizational cynicism among its members (Schilling and Kluge, 2009). "Creating a supportive organizational culture is a major challenge for companies aimed at effective KM" (Tong and Mitra, 2009). To do this, cultural barriers (Bureš, 2003; Rivera-Vazquez *et al.*, 2009; Tong and Mitra, 2009; Levy *et al.*, 2010) should be overcome, which can be in macro or micro levels. At the macro level, barriers act upon *cultural dimensions* of Hofstede (1983) and at the micro level, barriers have to do with the *organizational culture*, which is formed by national culture (Rivera-Vazquez *et al.*, 2009).
- *Strict rules and regulations*: In rigidly bureaucratic organizational cultures, knowledge exchanges are formal and hierarchical. While clear goals seem helpful in overcoming learning under ambiguity, strict rules and regulations concerning the execution of work might provide a barrier for learning because they reduce the degree of freedom for "thinking out of the box" or gaining new insights (Chinying Lang, 2001; Schilling and Kluge, 2009).
- *Unclear job description ("not my job" phenomenon) and/or strict job description*: When in an organizational context of strict division of labor, organizational members are rewarded for accomplishing their primary tasks, they will tend to just focus on their own job at the expense of thinking about a solution of the overarching problems of the group, department or even company because they are not regarded as their duty. This is famous as "*not my job" phenomenon*. In the absence of clear personal responsibilities, it seems reasonable to assume that an innovation cannot be successfully implemented (Schilling and Kluge, 2009). This is similar to the *not invented here* syndrome, which "describes the tendency to neglect, ignore or worst still, disparage knowledge that is not created within an individual's sphere of interest" (McLaughlin *et al.*, 2008). To avoid this barrier, job description should clearly identify what is expected of each organizational member and what is not (Schilling and Kluge, 2009). It seems that a minimal job description is necessary for any job. Both unclear job description and strict job description (two extreme points) are destructive, but the amount of the clarity depends on the type of the job from very routine jobs to very innovative jobs.
- *Decentralization (silo structure, turfism, with powerful departmental structures)*: Harmon (2007) explains how silo thinking (vertical view of the organization) focuses on the departments to make it as efficient as possible and ignores what is going on in the other silos, and so results in neglecting organization-wide problems. Hierarchical structure of the organization makes some difficulties in implementing

innovative ideas and keeping them alive (Schilling and Kluge, 2009) and inhibits knowledge flows as well (Riege, 2005; Rego *et al.*, 2009). In other words, high degree of labor division is negatively related to the development of new ideas concerning overarching problems (Schilling and Kluge, 2009).

- *Low knowledge retention rates of highly skilled and experienced staff/high employee and management turnover*: Professional staff leave the company due to mismatch of their positions and their skill, inappropriate rewards, etc. (Riege, 2005). As a consequence, their skills and knowledge are lost, especially if the relevant knowledge is implicit and, therefore, relatively difficult to store in technical systems or transfer to the other members. This ultimately leads to discontinuity and disruption of the organizational memory, which is a barrier to the implementation of new ideas (Schilling and Kluge, 2009).
- *Long-term organizational success*: Competence traps: Long periods of success can form a blockage to OL when existing competencies are exploited at the expense of exploring innovative practices, processes, products or structures. "Because of the high level of competence that organizations have developed in their established processes, they tend to perceive them as superior to other processes" (Schilling and Kluge, 2009).
- *Inconsistent organizational strategy, systems, policies, practices and KM processes*: This barrier exists when the organization overlooks to align and integrate its KM strategy and the way in which knowledge is created, shared (Chinying Lang, 2001; Riege, 2005; McLaughlin *et al.*, 2008) and perhaps stored and applied within the department or business unit. High turnover in top management might be a source of this kind of inconsistency.
- *Unprovenness*: The higher the degree to which knowledge is rated and is seen as useful based on the previous experience of the knowledge source, the less difficult it is to transfer it. Without a proven record of the past usefulness of knowledge, "it is more difficult to induce potential recipient to engage in knowledge transfer and to legitimize controversial integration efforts" (Szulanski, 1996; McLaughlin *et al.*, 2008). *Unprovenness* has a meaning very close to trust on the part of the recipient, which is explained as a people-related barrier, but unlike trust, it is an organizational barrier because creating a proven record of past usefulness is the duty of the organization.
- *Need for rewards*: Incentive plays a key role in the success of KM initiatives (Rego *et al.*, 2009; Ajmal *et al.*, 2010). Organizational goals cannot be achieved without integrating the concept of motivation and rewards to the employees (Singh and Kant, 2008). As it was explained in the people-related barriers, individuals should be motivated to create, share and use knowledge within the organization (Chinying Lang, 2001; McLaughlin *et al.*, 2008; Singh and Kant, 2008) and it is critical for both tacit and explicit knowledge (Singh and Kant, 2008). "The need for rewards is a people issue whereas the mechanism for conferring rewards is an organizational issue" (McLaughlin *et al.*, 2008).
- *Lack of formal authority on the part of the innovator and/or sponsor*: "It seems obvious that a lack of formal authority (e.g. not being part of the company's top management) on the part of the originator of the innovation, his/her champion(s) or supporter(s) proves a major obstacle for OL" (Schilling and Kluge, 2009). Although Schilling and Kluge suggested this barrier as an actional-personal barrier, the authors think that the one who defines formal authority is more related to the organization.
- *Lack of fit between innovation and organizational assumptions and beliefs*: The proposed innovative idea may not be integrated into organizational practice due to conflict with organizational assumptions, existing occupational mindsets and local

theories or even more generally with industrial recipes of an industry (Schilling and Kluge, 2009).

4.4 Barriers related to environment

Environmental barriers include the market, success criteria and environmental changes.

- *Proprietary knowledge:* Organization does not want to share its proprietary knowledge with suppliers/outsourced partners because this leaves it open to the risk that the information will be revealed (McLaughlin *et al*, 2008).
- *Time lag between organizational action and environmental response:* The time lag between an innovation and its success is an opportunity for opponents to take this as "proof" of its inefficiency, especially when the innovation challenges the structures and power relations that some key members prefer the current state (Schilling and Kluge, 2009).
- *Rapid technological change:* Long implementation time may make the innovation obsolete even if an organization is willing to implement new ideas. Furthermore, rapid environmental changes affect the implementation of innovation through making it unnecessary and outdated during a period of time (Schilling and Kluge, 2009).

4.5 Barriers related to characteristics of the knowledge

This category includes the abstract nature of knowledge and learning (McCann and Buckner, 2004) and characteristics of the knowledge itself.

- *Causal ambiguity:* Ambiguity exists in situations where an individual or group does not know exactly what the information/knowledge is supposed to be used for (McLaughlin *et al*., 2008). The more implicit and difficult the relevant knowledge and skills, the higher will be the ambiguity and therefore the less adaption by organizational members will be seen. The higher ambiguity implies that their speed of transfer and the risk of imitation by competitors will be decreased because knowledge and skills could not be easily coded and taught (Schilling and Kluge, 2009). Grundvag Ottesen and Grønhaug (2004) discussed that the attributes of the market orientation knowledge affect successful transfer of that knowledge from academia to practitioners. Sheng *et al.* (2013) showed that knowledge ambiguity has a negative relationship with knowledge transfer in healthcare settings.
- *Perceived irrelevance of the knowledge for future purposes:* If an organization concludes that certain learning results are irrelevant for the future purposes, then it ignores to store it. This is especially important in a dynamic organizational environment such as telecommunication, which is characterized by rapid technological changes (Schilling and Kluge, 2009). Benmoussa (2009) explained that "focusing on present requirements, not on what must be known to operate in the future" should be considered as a planning-related barrier to KM.

5. Data analysis

5.1 Demographic information

All respondents had an academic degree greater than a bachelor's degree. In the sample, 53 per cent of the participants had a BSc degree, 44 per cent MSc degree, 2 per cent PhD degree and 1 per cent did not reply to the education question. Although the questionnaire was designed to be responded by anyone who was familiar or unfamiliar with KM, to be confident of the lack of difference between the responses from those participants who were familiar with KM and those who were not, a question was included. In all, 71 per cent of the respondents were previously familiar with KM, 24 per cent were unfamiliar and 5 per cent did not respond to the related question. The results of the two independent-sample *t*-tests (Appendix 2) revealed that there were no differences between the responses from these two groups of participants. So, the authors did not separate them for running *t*-test.

Respondents were from various departments, as depicted in Table II. Respondents were from 13 departments including administration, commercial, engineering, exploitation, financial, Health Security, safety and Environment (HSE), human resource, IT, planning, repairing, R&D, supporting and system analysis (Table II). Kruskal–Wallis test revealed that there was no significant difference of KM process barriers among the respondents from various departments.

5.2 Empirical validation of the measures

Reviewing the literature and using experts' judgment on the given construct is an approach to ensure content validity (Churchill, 1979; Kerlinger, 1986). In relation to the content validity, the instrument has been constructed based on a broad review of the literature and has been reviewed by scholars and practitioners in KM. In addition, before running the survey, a draft questionnaire was pilot tested by five KM researchers (PhD) to ensure that the content and wordings were free from mistakes. Also, two participants from the gas and petroleum industry then examined the revised questionnaire. They were given the questionnaire and asked to examine it for meaningfulness, relevance and clarity.

5.3 Reliability

Cronbach's α statistic is commonly used to measure internal consistency of the instrument (Cronbach, 1951). Table III shows the estimation of the reliability according to Cronbach's coefficient α for the constructs measured in the study separately for generation, storage, distribution and application. All of them are acceptable and satisfactory for survey research (Guieford, 1965; Nunnally and Bernstein, 1994; Streiner, 2003). Therefore, the result derived from the questionnaire was highly stable and consistent.

6. Research results

For each of the four KM processes, the null hypothesis of *H0* and the alternative hypothesis of *H1* were assumed as follows:

H0. The average score of the importance of barrier in the gas and petroleum sector is 3.

H1. The average score of the importance of barrier in the gas and petroleum sector is greater than 3.

The results of the *t*-tests for each item are depicted in the table. All tests were calculated at a 95 per cent confidence level ($\alpha = 0.05$).

Table II Distribution of the answers from various organizational departments

Administration	*Commercial*	*Engineering*	*Exploitation*	*Financial*	*HSE*	*Human resource*
10	16	28	12	11	7	4
IT	Planning	Repairing	R&D	Supporting	System analysis	Without answer
4	21	12	4	46	6	9

Table III Reliability according to the Cronbach's coefficient α

Construct	*Number of items*	*Cronbach for generation*	*Cronbach for storage*	*Cronbach for distribution*	*Cronbach for application*
P (Person)	14	0.841	0.807	0.815	0.815
T (Technology)	5	0.741	0.72	0.754	0.748
O (Organization)	20	0.902	0.909	0.867	0.916
E (Environment)	3	0.718	0.78	0.758	0.751
K (Knowledge)	2	0.613	0.539	0.562	0.575

6.1 Identifying and ranking the barriers of knowledge generation, storage, distribution and application in the gas and petroleum sector

For knowledge generation, the *t*-tests rejected the null hypotheses for items P1, P11, P12, T1, O1, O2, O3, O8, Q10, O18, O19, O20, K1 and K2. Hence, the importance of the related barriers was recognized to be significant in knowledge generation. The Friedman test (chi-square = 53.57 and sig = 7.16 E-07) revealed that there is an important difference between the mean of the knowledge generation barriers. So, they were ranked according to their relevant mean from strongest (most influential) to weakest, as is shown in Table IV.

For knowledge storage, the *t*-tests rejected the null hypotheses for items P1, T1, O1, O2, O18 and O19. Hence, the importance of these barriers was recognized to be significant in knowledge storage. The Friedman test (chi-square = 11.67 and sig = 0.0395) demonstrated that there is an important difference between the mean of the knowledge storage barriers. So, the authors ranked them according to their relevant mean from strongest (most influential) to weakest, as is shown in Table V.

For knowledge distribution, the *t*-tests rejected the null hypotheses for items P1, P11, T1, O1, O2, O3, O5, O8, O18, O19, O20 and K1. Therefore, the importance of these barriers was recognized to be significant in knowledge distribution. The Friedman test (chi-square = 42.16 and sig = 1.51686E-05) revealed that there is an important difference between the mean of the knowledge distribution barriers. So, they were ranked according to their relevant mean from strongest (most influential) to weakest, as is shown in Table VI.

For knowledge application, the *t*-tests rejected the null hypotheses for items P11, P12, T1, O1, O2, O3, O5, O8, O16, O18, O19, O20, K1 and K2. So, the importance of these barriers was recognized to be significant in knowledge application. The Friedman test (chi-square = 54.34

Table IV Knowledge generation barriers

Barrier	t	*df*	*Sig. (2-tailed)*	*Mean*	*SD*	*Std. error mean*	*95 per cent confidence interval of the difference*	
							Lower	*Upper*
O18	10.08881	177	3.40E-19	3.820	1.08	0.0813	0.659782	0.980668
O1	8.673743	181	2.35E-15	3.650	1.02	0.075382	0.505105	0.802587
O19	6.824366	178	1.34E-10	3.590	1.15	0.085956	0.416969	0.756215
T1	6.073159	183	7.09E-09	3.540	1.21	0.087135	0.366916	0.72004
P1	5.438642	186	1.67E-07	3.470	1.17	0.085544	0.29648	0.634001
O20	5.05717	169	1.10E-06	3.420	1.09	0.083748	0.258202	0.588857
O3	4.036065	161	8.38E-05	3.360	1.13	0.088706	0.182847	0.533203
P12	3.647625	187	0.000343	3.340	1.28	0.093328	0.156315	0.524537
O8	3.980699	177	0.0001	3.330	1.09	0.081856	0.164304	0.487381
K2	3.733922	157	0.000263	3.320	1.07	0.084752	0.149055	0.483856
O2	3.586189	178	0.000433	3.310	1.17	0.087237	0.140697	0.485001
O10	2.879253	172	0.004493	3.270	1.21	0.088295	0.083613	0.448179
P11	3.077349	180	0.002415	3.240	1.06	0.078995	0.087219	0.398968
K1	2.444296	170	0.015535	3.200	1.1	0.083737	0.03938	0.369977

Table V Knowledge storage barriers

Barrier	t	*df*	*Sig. (2-tailed)*	*Mean*	*SD*	*Std. error mean*	*95 per cent confidence interval of the difference*	
							Lower	*Upper*
T1	6.770	184.000	0.000	3.605	1.220	0.089	0.429	0.782
O18	6.759	175.000	0.000	3.563	1.100	0.083	0.398	0.727
O1	6.335	176.000	0.000	3.503	1.050	0.079	0.346	0.659
O19	3.907	171.000	0.000	3.343	1.150	0.088	0.170	0.516
O2	2.786	175.000	0.006	3.256	1.220	0.092	0.075	0.437
P1	2.658	182.000	0.009	3.230	1.170	0.086	0.059	0.400

Table VI Knowledge distribution barriers

Barrier	t	df	Sig. (2-tailed)	Mean	SD	Std. error mean	95 per cent confidence interval of the difference Lower	Upper
O18	7.184	176.000	0.000	3.627	1.161	0.087	0.455	0.799
T1	6.925	184.000	0.000	3.605	1.189	0.087	0.433	0.778
O19	2.983	172.000	0.003	3.584	2.575	0.196	0.197	0.970
O1	5.951	176.000	0.000	3.475	1.061	0.080	0.317	0.632
O20	4.106	170.000	0.000	3.339	1.080	0.083	0.176	0.502
O8	3.571	175.000	0.000	3.301	1.119	0.084	0.135	0.468
P11	2.946	177.000	0.004	3.236	1.069	0.080	0.078	0.394
O3	2.630	163.000	0.009	3.226	1.098	0.086	0.056	0.395
O5	2.590	179.000	0.010	3.222	1.151	0.086	0.053	0.392
P1	2.558	180.000	0.011	3.221	1.162	0.086	0.051	0.391
O2	2.360	175.000	0.019	3.216	1.214	0.091	0.035	0.396
K1	2.279	172.000	0.024	3.197	1.134	0.086	0.026	0.367

and sig = 2.29587E-06) revealed that there is an important difference between the mean of the knowledge application barriers. So, the authors ranked them according to their relevant mean from strongest (most influential) to weakest, as is shown in Table VII.

6.2 Knowledge generation barriers in various companies

For studying the difference of the knowledge generation barriers between gas and petroleum companies, the Mann–Whitney test revealed that there is significant difference between gas companies and petroleum companies (Table VIII: sig = 0.006 < 0.05). Also it was studied for each item separately, and the results are reflected in the column 5 of Table VIII. The bold numbers depict that the priority of related item is not the same in gas and petroleum companies. Thus, the next step was to examine the importance of knowledge generation barriers in gas and petroleum disjointedly based on their relevant data. Columns 5-8 of Table VIII illustrate the mean and priority of each knowledge generation barrier in gas and petroleum.

6.3 Knowledge storage barriers in various companies

For studying the difference of the knowledge storage barriers between gas and petroleum companies, the Mann–Whitney test exposed that except T1, for others, there is no significant difference between gas companies and petroleum companies (Table IX: sig = 0.061 > 0.05).

Table VII Knowledge application barriers

Barrier	t	df	Sig. (2-tailed)	Mean	SD	Std. error mean	95 per cent confidence interval of the difference Lower	Upper
O18	8.821306	181	9.38E-16	3.752747	1.151203	0.085333	0.584372	0.921122
O1	7.148627	175	2.28E-11	3.642045	1.191515	0.089814	0.464788	0.819303
O19	6.728399	177	2.29E-10	3.629213	1.24766	0.093516	0.444663	0.813763
T1	6.340358	182	1.76E-09	3.57377	1.224193	0.090495	0.395216	0.752325
O2	5.176009	179	6.05E-07	3.483333	1.252818	0.09338	0.299067	0.6676
O20	5.559237	174	1E-07	3.474286	1.12861	0.085315	0.3059	0.642671
O8	4.660551	176	6.21E-06	3.39548	1.128949	0.084857	0.228012	0.562948
K1	4.000687	176	9.29E-05	3.355932	1.183639	0.088968	0.180351	0.531513
O3	3.383505	163	0.000896	3.323171	1.223171	0.095514	0.134567	0.511774
P12	3.442838	183	0.000713	3.320652	1.263358	0.093136	0.136894	0.504411
K2	3.256382	158	0.001381	3.314465	1.217688	0.096569	0.123733	0.505198
O10	3.166485	172	0.001826	3.312139	1.296562	0.098576	0.117565	0.506713
O16	3.269371	173	0.001301	3.310345	1.252146	0.094925	0.122985	0.497705
P11	2.768762	177	0.006226	3.247191	1.191124	0.089279	0.071004	0.423378
T4	2.050298	175	0.041827	3.193182	1.249987	0.094221	0.007225	0.379138
O5	2.020456	180	0.044818	3.187845	1.250807	0.092972	0.004391	0.3713

Table VIII Priority of knowledge generation barriers in gas and petroleum companies

K generation barriers	Mann–Whitney U	Wilcoxon W	z	Asymp. sig. (2-tailed)	Gas Mean	Gas Priority	Petroleum Mean	Petroleum Priority
CreaAverage	2832.000	11743.000	−2.760	**0.006**		-		
O1	3202.000	11203.000	−1.040	0.298	3.786	4	3.377	5
O18	3089.000	10964.000	−0.746	0.456	3.906	1	3.18	12
O20	2491.000	9994.000	−1.573	0.116	3.646	7	3.191	11
O19	2729.500	10479.500	−2.209	**0.027**	3.873	2	3.426	4
K2	2493.500	8379.500	−0.808	0.419	3.44	11	3.595	2
P11	3043.000	11299.000	−1.134	0.257	3.396	13	3.206	10
O8	3305.500	4790.500	−0.140	0.889	3.315	14	3.283	8
O3	2445.500	8886.500	−1.218	0.223	3.531	10	3.331	7
P1	3225.500	11740.500	−1.454	0.146	3.667	6	3.101	14
K1	2619.500	9879.500	−1.539	0.124	3.412	12	3.784	1
T1	2856.500	11241.500	−2.153	**0.031**	3.818	3	3.46	3
O2	2795.500	10796.500	−1.771	**0.077**	3.566	9	3.336	6
O10	2466.000	9606.000	−2.520	**0.012**	3.63	8	3.117	13
P12	2922.500	11568.500	−2.427	**0.015**	3.684	5	3.259	9

Table IX Knowledge storage barriers in various companies

K storage barriers	Mann–Whitney U	Wilcoxon W	z	Asymp. sig. (2-tailed)
StoAvera	3174.500	11952.500	−1.877	0.061
P1	3524.500	11399.500	−0.312	0.755
T1	2949.500	11334.500	−2.045	**0.041**
O1	3250.500	10753.500	−0.346	0.729
O2	2755.500	10258.500	−1.777	0.076
O18	3110.500	10736.500	−0.498	0.619
O19	2703.000	9963.000	−1.436	0.151

6.4 Knowledge distribution barriers in various companies

For studying the difference of the knowledge distribution barriers between gas and petroleum companies, the Mann–Whitney test uncovered that except T1, for others, there is no significant difference between gas companies and petroleum companies (Table X: sig = 0.075 > 0.05).

6.5 Knowledge application barriers in various companies

For studying the difference of the knowledge application barriers between gas and petroleum companies, the Mann–Whitney test revealed that there is significant difference between gas companies and petroleum companies (Table XI: sig = 0.003 < 0.05). Also it was studied for each item separately, and the results are reflected in the column 5 of Table XI. The bold numbers depict that the priority of related item is not the same in gas and petroleum companies. Thus, the next step was to examine the importance of the knowledge application barriers in gas and petroleum disconnectedly based on their relevant data. Columns 5-8 of Table XI illustrate the mean and priority of each knowledge application barrier in gas and petroleum.

6.6 Ranking KM barriers

Table XII illustrates the ranking of KM barriers according to their impact coefficient, which in turn was calculated for each barrier by multiplying the number of the influential KM processes (from 1 to 4) and the average mean of that barrier's importance in KM processes. The star sign means that the relevant barrier (column 1) has effect on KM processes (column 2-5).

7. Discussion

According to the results of Tables IV–VII, it can be discovered that:

- *The complete list of the barriers that impede knowledge generation include:* lack of an appropriate reward; critical knowledge is not well coupled with organizational goal

Table X Knowledge distribution barriers in various companies

K distribution barriers	*Mann–Whitney U*	*Wilcoxon W*	z	*Asymp. sig. (2-tailed)*
ShareAvera	3231.500	12142.500	−1.781	0.075
P1	3055.000	10930.000	−1.415	0.157
P11	3172.500	11173.500	−0.344	0.731
T1	2853.000	11238.000	−2.342	**0.019**
O1	3229.000	10732.000	−0.416	0.677
O2	3022.000	10525.000	−0.897	0.370
O3	2498.500	9168.500	−1.188	0.235
O5	3056.500	11057.500	−1.116	0.265
O8	2995.500	10255.500	−1.202	0.229
O18	3073.500	10699.500	−0.817	0.414
O19	2927.000	10308.000	−0.745	0.456
O20	2638.500	9898.500	−1.480	0.139
K1	3069.500	10209.500	−0.486	0.627

Table XI Knowledge application barriers in various companies

K application barriers	*Mann–Whitney U*	*Wilcoxon W*	z	*Asymp. Sig. (2-tailed)*	*Gas*		*Petroleum*	
					Mean	*Priority*	*Mean*	*Priority*
ApplyAvera	2782.500	11560.500	−2.996	**0.003**			-	
O18	3328.000	11078.000	−0.840	0.401	3.862	3	3.702	1
O20	2860.000	10120.000	−1.466	0.143	3.655	8	3.392	5
O1	3000.000	10381.000	−1.081	0.280	3.782	4	3.579	2
O8	3051.500	10432.500	−1.103	0.270	3.536	12	3.331	7
T1	2753.500	10881.500	−2.506	**0.012**	3.893	1	3.433	4
O19	2891.000	10517.000	−1.606	0.108	3.873	2	3.52	3
K1	2805.000	10308.000	−1.795	0.073	3.6	9	3.246	8
O2	2949.000	10699.000	−1.664	0.096	3.714	5	3.379	6
P11	2883.500	10884.500	−1.292	0.196	3.423	16	3.175	12
K2	2395.500	8281.500	−1.362	0.173	3.471	15	3.241	9
O3	2397.000	8725.000	−1.871	0.061	3.577	10	3.205	11
O16	2388.500	10138.500	−2.429	**0.015**	3.7	7	3.153	13
P12	3059.000	11187.000	−1.725	0.084	3.544	11	3.22	10
T4	2720.000	10101.000	−1.991	**0.046**	3.473	14	3.066	15
O10	2447.500	9468.500	−2.674	**0.007**	3.709	6	3.127	14
O5	2742.000	10743.000	−2.294	**0.022**	3.491	13	3.056	16

or costly errors that impede learning from previous failure and success; lack of formal authority on the part of the innovator; lack of technical support of integrated technology; lack of slack times and heavy workload; lack of fit between innovation and organizational assumptions; poor targeting of required information; lack of top management support; lack of teams, workgroups and communities of practice; knowledge focus on present requirements rather than on future purposes; lack of emphasis on OL and KM in vision, mission and objectives; the reluctance of recipient to accept knowledge from the outside (not invented here syndrome); staff' s ambiguity about what the information/knowledge is exactly supposed to be used for.

- *The complete list of the barriers that impede knowledge storage include:* lack of technical support of integrated technology; lack of an appropriate reward; critical knowledge is not well coupled with organizational goal or costly errors that impede learning from previous failure and success; lack of formal authority on the part of the innovator; lack of slack times and heavy workload.
- *The complete list of the barriers that impede knowledge distribution include:* lack of an appropriate reward; lack of technical support of integrated technology; lack of formal authority on the part of the innovator; critical knowledge is not well coupled with organizational goal or costly errors that impede learning from previous failure

Table XII Ranking knowledge management barriers

Barrier	Generation	Storage	Share	Apply	Number of KM process	AVE of mean	Impact coefficient	Priority
O18: Lack of an appropriate reward (financial incentive, reducing working hours, etc.) for acquiring new skills and knowledge, undertaking new projects or responsibilities, communicating ideas, etc.	*	*	*	*	4	3.69	14.76	1
T1: Lack of technical support of integrated technology to support KM tools requirements	*	*	*	*	4	3.58	14.32	2
O1: Critical knowledge is not well coupled with organizational goal or costly errors	*	*	*	*	4	3.57	14.28	3
O19: Lack of formal authority on the part of the innovator	*	*	*	*	4	3.54	14.16	4
O2: Lack of learning from previous failure and success due to a weak performance measurement system with clear criteria of success	*	*	*	*	4	3.32	13.26	5
O20: Lack of fit between innovation and organizational assumptions, existing occupational mindsets, beliefs, etc.	*		*	*	3	3.41	10.23	6
O8: Lack of teams, work groups and communities of practice for collaboration around work-related issues and challenges	*		*	*	3	3.34	10.02	7
P1: Lack of slack times and heavy workload	*	*	*		3	3.31	9.93	8
O3: Poor targeting of required information in order to generate needed knowledge in KM system	*		*	*	3	3.30	9.90	9
K1: Staff's ambiguity about what the information/ knowledge is exactly supposed to be used for	*		*	*	3	3.25	9.75	10
P11: The reluctance of recipient to accept knowledge from the outside (not invented here syndrome)	*		*	*	3	3.24	9.72	11
P12: Lack of top management support (supporting new ideas, establishing sufficient technical infrastructure, encouraging and so on)	*			*	2	3.33	6.66	12
K2: Knowledge is perceived to focus on present requirements rather than on future purposes in a dynamic organizational environment	*			*	2	3.32	6.64	13
O10: Lack of emphasis on organizational learning and KM as critical business advantages in vision, mission and objectives	*			*	2	3.29	6.58	14
O5: Poor coordination among functions caused by top-down leadership style			*	*	2	3.21	6.42	15
O16: Inconsistencies between strategy, systems, policies and practices				*	1	3.31	3.31	16
T4: Staff's reluctance to use integrated IT systems and tools due to lack of familiarity and experience with systems and tools				*	1	3.19	3.19	17

and success; lack of fit between innovation and organizational assumptions; lack of teams, workgroups and communities of practice; the reluctance of recipient to accept knowledge from the outside (not invented here syndrome); Poor targeting of required information; Poor coordination among functions; Lack of slack times and heavy workload; Critical knowledge is not well coupled with organizational goal or costly errors that impede learning from previous failure and success; Staff's ambiguity about what the information/knowledge is exactly supposed to be used for.

- *The complete list of the barriers that impede knowledge application include:* Lack of an appropriate reward; Critical knowledge is not well coupled with organizational goal or costly errors that impede learning from previous failure and success; Lack of formal authority on the part of the innovator; Lack of technical support of integrated technology; Lack of fit between innovation and organizational assumptions; Lack of teams, work groups and communities of practice; staff's ambiguity about what the information/knowledge is exactly supposed to be used

for; poor targeting of required information; poor coordination among functions; lack of top management support; knowledge focus on present requirements rather than on future purposes; lack of emphasis on OL and KM in vision, mission and objectives; inconsistencies between strategy, systems, policies, and practices; the reluctance of recipient to accept knowledge from the outside (not invented here syndrome); staff's reluctance to use integrated IT systems and tools; poor coordination among functions.

The total ranking of the most influential KM barriers in the gas and petroleum sector was calculated according to their impact on the four KM processes in Table XII. Figure 1 demonstrates the five most influential barriers and their impact in hindering knowledge generation, storage, distribution and application. Lack of reward, lack of technology, lack of formal authority on the part of the innovator and/or sponsor and lack of fitness between knowledge and important organizational goals, which impede learning from previous failure and success, were the most important KM barriers, which affect knowledge generation, storage, distribution and application in gas and petroleum companies.

Moreover, Mann–Whitney test revealed that the importance of knowledge storage and knowledge distribution is the same for gas and petroleum companies, but for knowledge generation and knowledge application, the barriers were significantly different between gas and petroleum companies (Tables VIII and XI). The five most important barriers that hinder knowledge generation in gas companies are: lack of an appropriate reward; lack of formal authority on the part of the innovator; lack of technical support of integrated technology; critical knowledge is not well coupled with organizational goal or costly errors that impede learning from previous failure and success; and lack of top management support.

While the five most effective barriers among knowledge application barriers in petroleum companies are: staff's ambiguity about what the information/knowledge is exactly supposed to be used for; knowledge is perceived to focus on present requirements rather than on future purposes in a dynamic organizational environment; lack of technical support of integrated technology; lack of formal authority on the part of the innovator; and critical knowledge is not well coupled with organizational goal or costly errors that impede learning from previous failure and success.

The most important barriers that impede knowledge generation in gas and petroleum companies are compared in Figure 2.

Figure 1 The five most influential barriers and their importance

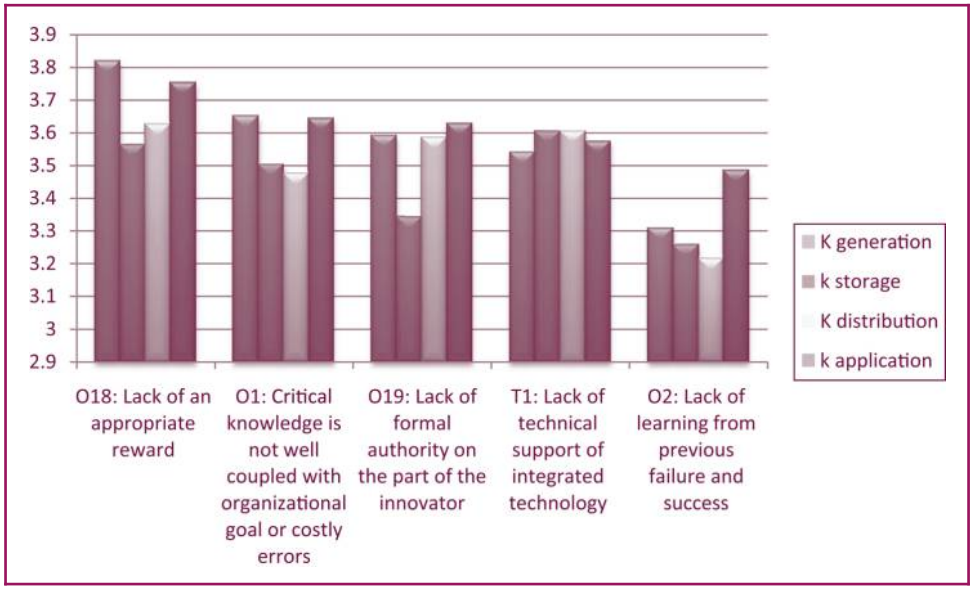


Figure 2 The most important barriers that impede knowledge generation in gas and petroleum companies

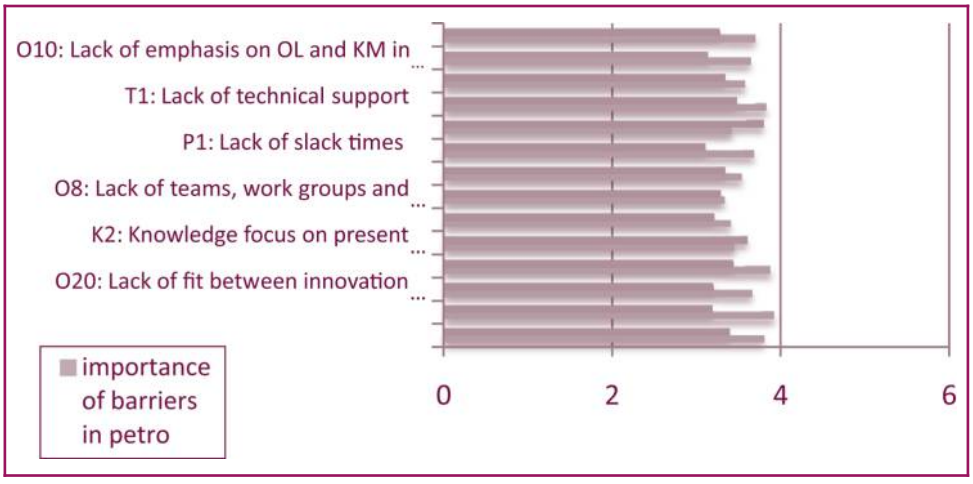


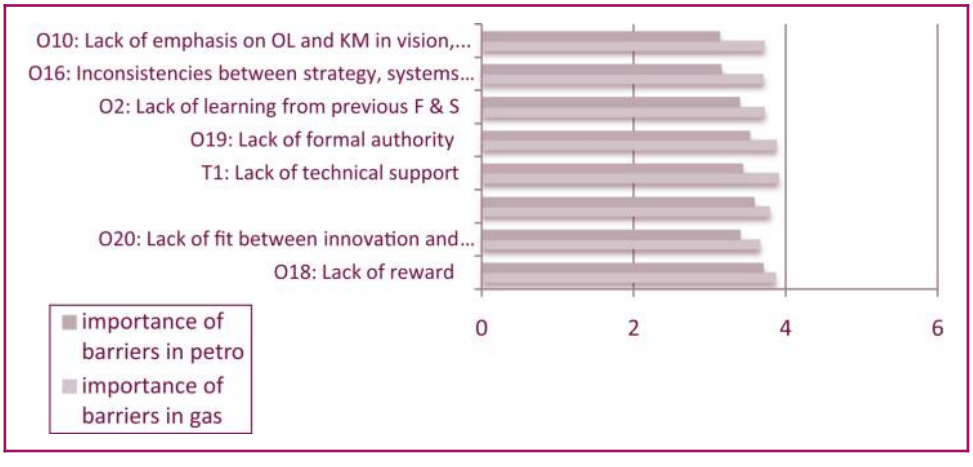
Figure 3 compares the most effective barriers of knowledge application in gas and petroleum companies.

Also, the importance of the technology barrier for knowledge storage and distribution is not the same for gas and petroleum companies (Tables V and VI).

8. Conclusion

The barriers of KM processes impede generation, storage, distribution and application of knowledge, which in turn lead to hinder OL. This paper reviewed the current literature of KM barriers and offers a holistic list of them in five categories including people-related barriers, technology-related barriers, organization-related barriers, environment-related barriers and knowledge characteristic-related barriers. Also, it validated and ranked the barriers of knowledge generation, storage, distribution and application in the gas and petroleum sector. Furthermore, this paper found that the importance of knowledge generation and knowledge application barriers was significantly different between gas and petroleum companies. Hence, it disjointedly ranked the aforementioned barriers for gas and petroleum companies. Finally, KM barriers were ranked according to the number of their

Figure 3 The most effective barriers of knowledge application barriers in gas and petroleum companies



contribution to KM processes and the average mean of their importance in KM processes. Lack of reward, lack of technical support, lack of formal authority on the part of the innovator and lack of fitness between knowledge and important organizational goals, which hinder learning from previous failure and success, were the most important KM barriers, which affect knowledge generation, storage, distribution and application in gas and petroleum companies. The other influential barriers were ranked and reported too.

Little research has paid attention to ranking KM barriers, especially considering their effect on the KM processes. This study contributes to fill the aforesaid gap existing in the literature using *t*-test for identifying the most important barriers in terms of each KM process in the gas and petroleum sector and ranking them based on their mean (Tables IV–VII). When compared with similar existing literature, this paper has not only completely reviewed KM barriers, but also discussed about the most influential KM barriers and their effect on knowledge generation, storage, distribution and application in gas and petroleum companies. Moreover, KM barriers were ranked based on the number of their contribution to KM processes and the average mean of their importance in KM processes.

Ranking of the KM barriers will determine the priority of solving them. Furthermore, different barriers will need different solutions. How barriers impact the KM processes will aid to select the type of desirable solution. From the practical point of view, concentrating on the most important KM processes for KM barriers identification and ranking may provide a guide as to how managers of the gas and petroleum sector could emphasize on solving those high-priority barriers, which are more important according to that KM process, which they are focused on. For example if the knowledge strategy of a gas company is concentrated on promoting knowledge application, then according to Table XI, the managers of that company should emphasize first on developing an appropriate KMS, second on reviewing the formal authority of the knowledge workers, third on motivating people to apply knowledge, etc. However, it is proposed to managers of petroleum companies in the same situation to emphasize first on motivating people to apply knowledge, second on clearing what knowledge is critical to keep for avoiding costly errors and achieving organizational goals, third on reviewing the formal authority of the knowledge workers, etc. Furthermore, this study provides a checklist for managers to evaluate the status of KM barriers in their companies, which can be served for developing KM readiness measures too.

In spite of Karabag's (2010) findings that emphasize on the role of the human critical success factor (CSFs) for the successful implementation of KM and reported a less important role for organizational and technical CSFs, our results showed that the most effective barriers belong to the organizational issues. In fact, organization's maturity seems to affect KM processes. Cumberland and Githens (2012) discussed about the effect of organizational maturation on knowledge sharing in a franchise system.

This paper limits to intra-organizational KM processes, so a similar future study can be repeated for inter-organizational KM barriers, which persist on inter-organizational KM processes such as knowledge transfer and knowledge acquisition. Also, the results may limit to the gas and petroleum companies due to the sample of this study.

Some researchers discussed about the ways of overcoming KM barriers; for example, Cantoni *et al.* (2001) developed a model for overcoming knowledge creation barriers of employees by using appropriate training, incentives, technology and structure. Riege (2007) provided a

"The barriers of KM processes impede generation, storage, distribution and application of knowledge, which in turn lead to hinder OL."

"This study provides a checklist for managers to evaluate the status of KM barriers in their companies, which can be served for developing KM readiness measures."

comprehensive list of actions to prevail over a wide range of knowledge transfer barriers. McDermott and O'Dell (2001) reported a number of approaches such as tying sharing knowledge to a preexisting core value, matching KM with the organization's style, etc., to solve knowledge-sharing cultural barriers. Cumberland and Githens (2012) provided some ideas to foster knowledge sharing such as recognizing and valuing each player's contribution to the knowledge-sharing relationship. Further research may discuss about the customized solution to overcome KM barriers in the gas and petroleum sector. Moreover, it is worthy to note that there are some relationships among the barriers. Wendling *et al.* (2013) discovered the relationships between knowledge-sharing barriers in global teams, for example cultural differences are negatively related to absorptive capacity. Future research may provide more evidence to clear these relationships.

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Appendix 1. Questionnaire

The enclosed questionnaire is a part of my PhD research. This is an academic research focused on identifying and ranking barriers which affect KM processes (generation, storage, distribution and application of knowledge). Please take a moment to complete this short questionnaire.

Your responses will only be used for scientific purpose. All results will be kept confidential and you will not be contacted about the results unless you so desire. I greatly appreciate your time and help for my research, so I take the opportunity to thank you in advance.

A brief definition of each KM process (columns) is as below:

- *Knowledge generation*: is about generating or discovering new knowledge through R&D, experimentation, lessons learned, creative thinking and innovation. This is the most advanced stage of KM.
- *Knowledge storage*: means storing existing, acquired and created knowledge in properly indexed and inter-linked knowledge repositories.
- *Knowledge distribution*: is the process of sharing and spreading knowledge which is already present within the organization which occurs between a source and recipient unit.
- *Knowledge application*: means retrieving and using knowledge in support of decisions, actions, problem-solving, automating routine work and providing job aids and training.

Figure A1

Questionnaire

Please fill the table according to the impact of the barrier in each row on the different KM processes that appear in the columns. This impact should be determined by numbers from 1 to 5 as follows:

1: very low **2**: low **3**: medium **4**: high **5**: very high

If you think that a barrier is unrelated to a KM process please leave the related cell without answer.

The name of your company: Organizational department:

Your Education: B.Sc. ☐ M.Sc. ☐ Ph.D. ☐

Previous familiarity with KM: Yes ☐ No ☐

Barriers	Code	Impact of this barrier on KM processes			
		Generation	Storage	Distribution	Application
lack of slack times and heavy workload	P1	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Fear of loss of ownership and control of individual knowledge property	P2	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Fear of one-way flow of knowledge from source to recipient but not vice versa	P3	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Lack of trust in the source of the knowledge for giving the right knowledge	P4	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Lack of trust in the recipient of the knowledge for exploiting of knowledge	P5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Lack of ability of recipient to exploit the external knowledge (absorptive capacity)	P6	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Lack of ability of recipient to use the new knowledge as routines through institutionalization (retentive capacity)	P7	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Staffs lack skills in expressing effectively any thought or information	P8	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
High level of stress because a fear of penalty, losing profit or offering inadequate or unimpressive knowledge	P9	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Leader's exaggeration about success and covering up failure, lead to incorrect conclusions on the impact of new ideas on organization	P10	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
The reluctance of recipient to accept knowledge from the outside (not invented here syndrome)	P11	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Lack of top management support (supporting new ideas, establishing sufficient technical infrastructure, encouraging and so on)	P12	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Innovation is regarded as a threat by people who are supposed to implement it (innovation is not compatible with their own interest)	P13	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Different levels of education, experience, age and other personal characteristics	P14	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Lack of technical support of integrated technology to support KM tools requirements	T1	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Trash information (mountains of information in IT tools)	T2	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Problems with connecting old IT tools of multiple departments	T3	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Staff's reluctance to use integrated IT systems and tools due to lack of familiarity and experience with systems and tools	T4	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Staff's unrealistic expectations of what KM tools can do	T5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Critical knowledge is not well coupled with organizational goal or costly errors	O1	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Lack of learning from previous failure and success due to a weak performance measurement system with clear criteria of success	O2	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Poor targeting of required information in order to generate needed knowledge in KM system	O3	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Geographical distance related to physical work environment and layout of work areas in the organization	O4	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Poor coordination among functions caused by top-down leadership style	O5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Employees don't know who know what and what was done before	O6	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Poor vertical communication caused by laissez-faire leadership styles	O7	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Lack of teams, work groups and communities of practice for collaboration around work-related issues and challenges	O8	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Punishing employees for deviating from norms or regulations	O9	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Lack of emphasis on organizational learning and KM as critical business advantages in vision, mission and objectives	O10	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Strict rules, regulations and Strict job description which impede "thinking out of the box"	O11	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Unclear job description ('not my job' phenomenon)	O12	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Decentralization & silo structure (vertically view of the organization)	O13	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
High turnover in highly skilled and experienced staff	O14	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Over-exploitation of processes, products, initiatives... as a consequence of their proven success, with a result of low explorative efforts	O15	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Inconsistencies between strategy, systems, policies and practices	O16	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Lack of a proven record about helpfulness of knowledge in the previous experiences	O17	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Lack of an appropriate reward (financial incentive, reducing working hours, etc.) for acquiring new skills and knowledge, undertaking new projects or responsibilities, communicating ideas, etc.	O18	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Lack of formal authority on the part of the innovator	O19	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Lack of fit between innovation and organizational assumptions, existing occupational mindsets, beliefs, etc.	O20	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
The risk of revealing organization's proprietary knowledge to the suppliers/outsourced partners	E1	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Innovation 's time to market (the time lag between an innovation and its initial market sale)	E2	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Effect of rapid environmental changes on the implementation of innovation through making it unnecessary and outdated	E3	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Staff' s ambiguity about what the information/knowledge is exactly supposed to be used for	K1	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Knowledge is perceived to focus on present requirements rather than on future purposes in a dynamic organizational environment	K2	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Appendix 2

Table AI The results of the 2 independent sample *t*-test

Barriers	*Mann-Whitney U*	*Wilcoxon W*	*Grouping Variable: KMknowledge* *Z*	*Asymp. Sig. (2-tailed)*
P1	3631.5	5009.5	−0.02569	0.979507
P2	3261.5	12991.5	−0.66187	0.508051
P3	3,189	12,919	−1.09032	0.275573
P4	3634.5	13504.5	−0.01663	0.986728
P5	3,077	12,668	−1.37402	0.169436
P6	3,049	12,365	−1.31274	0.189272
P7	3007.5	12737.5	−1.2506	0.211079
P8	3,553	13,564	−0.3382	0.735216
P9	3234.5	13104.5	−1.2363	0.216347
P10	3,081	11,992	−0.36718	0.713481
P11	3,315	4,641	-0.62943	0.529065
P12	3432.5	13162.5	−0.54885	0.583111
P13	3,337	12,928	−0.35345	0.723753
P14	3,535	4,913	−0.23868	0.811351
T1	3,097	4,322	−0.96936	0.332368
T2	3,164	12,480	−0.94343	0.34546
T3	2,936	12,116	−1.19437	0.232331
T4	3216.5	4441.5	−0.21449	0.830165
T5	2,995	11,380	−0.34373	0.731046
O1	3185.5	12776.5	−0.61897	0.535935
O2	3,480	13,071	−0.12033	0.90422
O3	2,750	10,878	−0.16094	0.872141
O4	3,295	4621	−0.39098	0.695811
O5	3,373	12,826	−0.58334	0.559666
O6	3437.5	13167.5	−0.53506	0.592608
O7	2,770	11,681	−1.96725	0.049154
O8	2,508	12,099	−2.75213	0.005921
O9	2,888	11,144	−0.84867	0.396066
O10	2,808	11,719	−1.26071	0.207414
O11	3,112	12,023	−0.04521	0.963937
O12	2,576	12,029	−1.89525	0.058059
O13	2178.5	9318.5	−0.59127	0.554339
O14	3293.5	4568.5	−0.25873	0.795843
O15	3094.5	4270.5	−0.24571	0.805904
O16	3,056	4,281	−0.73356	0.46322
O17	2733.5	11511.5	−1.44733	0.147806
O18	3,337	4,612	−0.27819	0.78087
O19	3467.5	4793.5	−0.00157	0.998748
O20	3329.5	4554.5	−0.00802	0.993604
E1	2753.5	11138.5	−0.5282	0.597362
E2	1,972	7,858	−1.68104	0.092754
E3	2444.5	8999.5	−0.02634	0.978989
K1	3211.5	4436.5	−0.38608	0.699436
K2	2646.5	3592.5	−0.15397	0.877632

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