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Emerald Article: Organizational factors to support knowledge management and innovation

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Abstract

Purpose – *The purpose of this paper is to analyze how organizational factors such as cultural values, leadership and human resource (HR) practices influence knowledge exploration and exploitation practices and innovation via an empirical study.*

Design/methodology/approach – *From the knowledge-based view of the firm, six hypotheses were established and statistically tested in a sample of 111 Spanish companies belonging to innovative industries. Survey methodology was used with the aim of gathering data regarding knowledge management (KM) practices and certain, related organizational aspects in firms.*

Findings – *This paper provides evidence of a moderating effect of knowledge-centered culture, knowledge-oriented leadership and knowledge-centered HR practices in the relationship between knowledge exploration and exploitation practices and innovation outcomes of companies. In line with previous literature, it is suggested that although KM practices are important on their own for innovation purposes, when certain enablers – organizational factors to overcome human barriers to KM – are properly established, the innovation capacity of the firm can be more successfully exploited.*

Research limitations/implications – *The research is limited to high rate innovation industries. Future studies will include other industries and a more diverse sample of firms.*

Practical implications – *The results of this study suggest that managers should place attention on knowledge exploration and exploitation practices along with several organizational enablers in order to achieve high levels of innovation results for the company.*

Originality/value – *This paper provides new empirical evidence on the relationships between KM, organizational elements such as culture, leadership, HR practices, and innovation in a large sample of firms. To date, the empirical research of these relations has been mainly limited to descriptive case studies and there is thus a lack of empirical evidence with large samples of firms.*

Keywords *Knowledge management, Exploration, Exploitation, Human resource practices, Culture, Leadership, Innovation*

Paper type *Research paper*

1. Introduction

In recent years, knowledge management (KM) has been recognized as a key instrument for the improvement of organizational effectiveness and performance (Zack *et al.*, 2009). Moreover, the importance of KM within organizations has dramatically risen due to factors such as growing globalization, the acceleration in the rate of technological change, or the need to share best practices (Zack, 1999a; Mehta, 2008). From the knowledge-based view of the firm (Kogut and Zander, 1992; Grant, 1996; Spender and Grant, 1996), knowledge is considered the most important strategic resource for ensuring an organization's long-term survival and success since some forms of complex knowledge, such as capabilities or routines can be valuable, scarce and difficult to imitate (DeCarolis and Deeds, 1999). Consequently, processes and practices that firms utilize in order to manage knowledge are

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instrumental for attaining strategic objectives by harnessing complexity and making the best use of existing resources and capabilities (Zack, 1999a; Zollo and Winter, 2002).

In this paper, the effect of KM practices on innovation is addressed, considering that the existence of these instruments (i.e. practices) is a necessary but not a sufficient condition in order to achieve optimal effectiveness from KM initiatives. From this viewpoint, the authors will try to analyze the role of certain moderating factors that may influence the way KM practices are utilized – in quantity and quality – by organizational members to develop knowledge exploration and exploitation (March, 1991).

Following DeTienne *et al.* (2004) and Mehta (2008), the key factors that contribute in general terms to effective KM are human and technical. This study will focus specifically on influential factors for overcoming human barriers associated with knowledge generation, codification, sharing and application[1]. Bollinger and Smith (2001) propose that human behavior is the key to success or failure of KM activities, as KM involves an emphasis on organizational culture, teamwork, the promotion of learning, and the sharing of skills and experience. From this viewpoint, three supporting human-related elements for KM success will be considered: culture, leadership and HR practices. According to Schein (1985), culture is ultimately about the control of behavior and so may be either an advantage or a disadvantage for the organization in order to achieve its main objectives; organizations should thus promote a series of values that influence behaviors and the willingness to share knowledge (Sveiby and Simons, 2002: 421; Leidner *et al.*, 2006). In addition, managers have to stimulate their members to voluntarily transfer their talent to support knowledge creation and application; in this sense, facilitating and coaching roles of leadership should be developed (Roth, 2003; Yang, 2007). Finally, specific HR practices such as training, teamwork or incentives should be implemented to foster knowledge sharing and creation in organizations (Currie and Kerrin, 2003; Cabrera and Cabrera, 2005; Chen and Huang, 2009).

KM activities can be generally grouped into areas such as exploration – knowledge generation – or exploitation – knowledge application (Grant, 2002: 179). Exploration activities are those related to the obtaining of new knowledge for generating new processes or products, while exploitation practices as those utilized to leverage existing knowledge (Grant, 2002; He and Wong, 2004). One concern for many strategic and organizational theorists has been the consideration of these two components, exploration and exploitation, as mutually exclusive or complementary, depending on issues such as the technological trajectory of the company, environmental conditions or others (Gupta *et al.*, 2006; Revilla *et al.*, 2010). In this study, knowledge exploration and exploitation will be considered as two separate constructs, recognizing that firms may establish ambidexterity strategies in KM (high level of development for both exploration and exploitation) and that a series of facilitators may affect these KM processes distinctively to gain more innovation.

By facilitators the authors mean those factors oriented towards the development of an internal environment for boosting KM initiatives, since they allow interactions among organizational members to be increased, the sharing of more ideas, experimentation, and willingness to codify, transfer and apply more knowledge for innovation (Bierly and Daly, 2002; DeTienne *et al.*, 2004; Jansen *et al.*, 2006; Singh, 2008). In other words, the more a firm uses knowledge-centered HR practices, develops a knowledge-centered culture, and follows a knowledge-oriented leadership, the greater the impact of exploration and exploitation activities on its innovation results will be.

In this study, innovation will be considered as the dependent measure since it has been recognized as a direct result of KM effectiveness and one of the main objectives for knowledge-creating companies in order to obtain competitive advantages (Nonaka, 1994; Nonaka and Takeuchi, 1995). Moreover, it is recently quite common for studies that investigate KM and intellectual capital to use innovation as an organizational outcome (see, e.g. Youndt and Snell, 2004; Subramaniam and Youndt, 2005; Chen and Huang, 2009). The research will be tested on a sample of high-tech firms as technological innovation is considered a strategic success factor (Pavitt, 1984) and both knowledge exploration and

exploitation are essential activities for companies in order to achieve competitive advantages (He and Wong, 2004; Gupta *et al.*, 2006).

The results of this study will show that organizational facilitators are essential in order to capitalize on efforts made in KM. One of the most important contributions of this work is that the moderating effects are found in both exploration and exploitation practices, meaning that both processes are essential for innovation and that certain organizational conditions have to be established in order to fully exploit KM strategies, in line with the results obtained in other empirical studies (see, e.g. Jansen *et al.*, 2006; Miller *et al.*, 2007). Being KM an emerging discipline, empirical studies on the effect of KM on organizational performance are necessary in order to establish a common and solid ground for researchers and practitioners (Alavi and Leidner, 2001; Jansen *et al.*, 2006). Although the number of these studies has increasingly grown in the last few years, a large amount of them are qualitative-based and carried out through case study methodology (Chen and Huang, 2009; Zack *et al.*, 2009). One of the main contributions of this paper, therefore, will be a quantitative research regarding KM practices on innovation in a large sample of firms.

The organization of this paper is as follows. First, the theoretical background and the research questions of this study will be established. Second, the empirical analysis will be presented along with the main results of the research. Next, the results of the study will be discussed. Finally, the main conclusions, limitations of the paper, and potential lines of research for the near future will be presented.

2. Theoretical background and research questions

KM and the knowledge-based view

Recent work in economic and management literature is contributing to develop a knowledge-based theory of firm, which places creation, integration, and the utilization of knowledge as the primary reason for their existence (Kogut and Zander, 1992; Nonaka, 1994; Grant, 1996). The knowledge-based view has its main foundation in the resource-based view (RBV) of the firm which focuses on strategic assets as the main source of competitive advantages (Barney, 1986; Amit and Schoemaker, 1993). It can be thus inferred that knowledge is the main strategic resource and when properly managed, it allows the firm to create economic, social, intellectual and cultural value (DeCarolis and Deeds, 1999; Zack *et al.*, 2009). The firm can thus be understood as a knowledge-bearing entity that manages its knowledge resources through its combinative – dynamic – capabilities (Kogut and Zander, 1992). From this perspective, it is recognized that knowledge resources underlie the company's products and services, and at the same time, that a firm utilizes its organizational capability to continually create new knowledge resources and exploit those that already exist (Nonaka, 1994).

In basic terms, KM comprises a set of processes through which knowledge is acquired, developed, gathered, shared, applied and protected by the firm in order to improve organizational performance (Oliveira, 1999; Alavi and Leidner, 2001; Grant, 2002; Zacka *et al.*, 2009). From a strategic viewpoint, Grant (2002, pp. 177-8) considers two types of KM contributions for academics and practitioners. On the one hand, there is recognition of the existence of two kinds of knowledge – explicit and tacit – with different characteristics and organizational implications for the firm. On the other hand, the management of knowledge processes that are focused on generating and exploiting knowledge also carries importance. Under this guise, knowledge is the firm's main strategic resource and it allows the organization to achieve and hold competitive advantages when it is effectively managed (Kogut and Zander, 1992; Grant, 1996; Zack *et al.*, 2009).

In this context, a KM strategy deals with the knowledge requirements of the firm regarding the application of its business strategy (Zack, 1999a). A company should establish these requirements by identifying, assessing and mapping its knowledge assets along with environmental conditions in which its business activities are developed (Zack, 1999a; Grant, 2002). Once the knowledge ''gap'' has been identified, concrete KM actions –strategy– should be developed in order to acquire or build up new knowledge, and at the same time

exploit the current knowledge base in line with business and corporate strategies. At this point, it is extremely important to pay attention to the infrastructures that are needed to implement and support KM strategies and initiatives in the firm, such as information technology (IT) systems and the human factor (DeTienne *et al.*, 2004; Mehta, 2008).

On the one hand, technological infrastructures are IT applications and systems that help organizations to gather, structure, give access, transfer or apply explicit knowledge through integrative applications such as document repositories (Zack, 1999b), assist individuals to convert explicit knowledge into tacit (internalization), tacit knowledge to explicit (exteriorization) or combine explicit knowledge (Nonaka, 1991; Nonaka and Takeuchi, 1995), and allows the exchange of tacit knowledge through interactive applications such as discussion forums, multimedia based applications, etc. (Zack, 1999b; Mehta, 2008). On the other hand, human infrastructures can be understood as support tools or practices that companies utilize to purposely commit people in order for KM strategies to be implemented, such as the assignation of responsibilities or KM roles, the existence of a collaborative culture, incentives for people to collaborate in KM initiatives, evaluation of KM performance, or training employees in specific KM tasks (Ruggles, 1998; Davenport and Prusak, 1998).

Since the emergence of KM as a discipline over two decades ago, technological aspects related to KM have been widely studied (DeTienne *et al.*, 2004; Yang, 2007). In the last few years, there has been an increased focus on people management and human-related supporting factors for KM, although there is still a lack of empirical evidence collected to date in relation to the analysis of enablers for KM effectiveness (DeTienne *et al.*, 2004; Yang, 2007; von Krogh *et al.*, 2011). The aim in this paper is to contribute to KM literature via a quantitative study of the moderating effects of these supporting factors in the relationship between KM practices and innovation. Next, all these aspects will be analyzed along with their relationships with knowledge exploration and exploitation practices and innovation.

Knowledge-centered culture, KM practices and innovation

In general terms, culture can be understood as a set of rules, values and beliefs that are shared by a firm's members (Schein, 1985). This concept has been linked to implicit aspects, sometimes of an abstract nature, such as ideologies, beliefs, basic assumptions of behavior or shared values, although other more observable and explicit elements such as rules and organizational practices, symbols, language, rituals, myths and ceremonies have also been considered as being related to culture (Alavi *et al.*, 2005, p. 194).

The KM research stream on organizational culture has essentially focused on values which encourage or hinder knowledge processes of creation and sharing (Alavi *et al.*, 2005). For example, DeTienne and Jackson (2001, p. 6) point out that if an environment which encourages the sharing of knowledge by providing expectations and incentives does not exist, KM implementation will result in a failure for the organization. In respect of KM strategies development, Earl (2001) and Garavelli *et al.* (2004) include ''knowledge culture'' as an essential factor which makes implementation easier, along with other elements such as leadership, human resources practices or the organizational structure. In a similar vein, Gold *et al.* (2001) showed that a relationship existed between certain organizational values – which were integrated in the so-called ''knowledge infrastructure capacities'' of the firm along with technology and structure – KM capabilities and a measure of organizational effectiveness. These authors suggest that organizations that have values oriented towards openness and trust are prepared to develop behaviors through which the employees share more ideas and knowledge, which in turn implies they can be more innovative, responding more easily and rapidly to changes and new market opportunities.

In addition, DeLong and Fahey (2000) identified several values which, from their viewpoint, encourage or hinder the creation, transfer and use of knowledge by the firm. They suggest that while trust and cooperation may lead the employees to share knowledge, the value systems which highlight individual power and competition would imply the adoption of behaviors that lean towards hoarding knowledge in order to dominate and maintain the status quo. In a similar vein, Jarvenpaa and Staples (2003) showed that organizational, shared values have an important influence on the willingness of knowledge owners to share

knowledge with other organizational members. Other studies obtain similar conclusions, albeit they only focus on the knowledge creation process. Lee and Choi (2003), for example, found a positive relationship between organizational culture – defined as a set of values that includes cooperation, trust and learning – and the improvement of the knowledge creation process. Similarly, Lee and Cole (2003) assert that culture acts like a social control mechanism which, depending on whether it promotes critical awareness and open behavior or if instead, it is oriented towards a system that looks to sanction an individual who operates outside of the rules, this will ultimately stimulate or hinder the processes that enables knowledge to be created and disseminated throughout the organization.

Considering a broader view of KM processes, several empirical studies have found a positive and direct effect of knowledge-centered cultural values on KM effectiveness (e.g. Jarvenpaa and Staples, 2003; Lee and Choi, 2003; Lee and Cole, 2003; Leidner *et al.*, 2006; Yang, 2007;) and indirect effects, in which culture plays a mediating role when it is understood as collaborative or cooperative learning for further innovation (Janz and Prasarnphanic, 2003) or as a moderator by improving the effectiveness of KM technologies (Alavi *et al.*, 2005). Within that research stream of indirect effects, Donate and Guadamillas (2010) found that culture works as an important moderating factor in the relationship between storage and transfer practices and the technological innovation results – both in products and processes – in a large sample of Spanish firms.

Overall, the issue behind all these studies is the manner in which culture influences the development and results of KM practices and processes. In this sense, the promotion of certain values such as openness and confidence, tolerance of errors or shared objectives will favor behaviors that influence KM and their outcomes, among which the improvement of the innovation capacity is included (Davenport *et al.*, 1998; DeLong and Fahey, 2000).

In this study and following Gupta *et al.* (2006), exploration and exploitation are considered as two separate constructs (i.e. a firm could pursue an ambidexterity KM strategy with high levels of both exploration and exploitation) and not as two extremes of a continuum in the same construct. Taking this differentiation into account, knowledge-centered cultural values could distinctively affect knowledge exploration and exploitation, although the suggested effect on innovation is an increase for both kinds of practices. It is thus emphasized in this research the aspect of creating a collaborative climate for reinforcing the exploration and exploitation of knowledge through a knowledge-centered culture. This kind of culture will favor the sharing of ideas, knowledge and experimentation – which it is at the core of exploration activities for innovation – and the use of IT applications along with greater willingness to codify, transfer and apply knowledge – which it is essential for exploitation activities connected to innovation (Bierly and Daly, 2002; Miller *et al.*, 2007). In line with this positioning and previous research, in this study it is therefore suggested the existence of a moderating role of knowledge-centered values in the relationship between KM practices – exploration and exploitation – and their results in terms of innovation. The following hypotheses are thus proposed:

H1. The greater the orientation of the firm towards a knowledge-centered culture, the higher the level of influence of knowledge exploration practices on innovation results.

H2. The greater the orientation of the firm towards a knowledge-centered culture, the higher the level of influence of knowledge exploitation practices on innovation results

Knowledge-oriented leadership, KM practices and innovation

As KM is based on the ability of a firm's members to add value to business processes through the creation, sharing, codification and integration of explicit and tacit knowledge, organizational leaders play an essential role (Nonaka and Takeuchi, 1995). This role is based on stimulating a firm's members to voluntarily transfer and applying their talent and ongoing experience for knowledge creation and sustained organizational competitiveness (Yang, 2007, p. 530). Leaders should thus contribute to propel KM by encouraging experimentation

and facilitating knowledge sharing through empowerment, coaching and trust (Bollinger and Smith, 2001; Roth, 2003; Haas and Hansen, 2005).

A number of studies have analyzed organizational leaders from a KM perspective, although limited empirical evidence has been contributed showing relationships among KM processes, leadership and innovation. Following von Krogh *et al.* (2011), the studies regarding leadership in KM can basically be divided into style theory, and prescriptive theory for leadership action.

The style theory holds the assumption that certain specific styles are more suitable than others for supporting KM activities, i.e. leaders should have certain qualities or behaviors, playing roles such as ''innovator'', ''mentor'' or ''facilitator'', all of which Yang (2007) finds to be positively related to knowledge sharing in organizations. Yang (2007) also found that styles involving strict policies and procedures will be less supportive for KM than those based on the promotion of human interaction, affiliation, morale, cohesion, and workplace harmony. Similarly, Singh (2008) found that consulting and delegate modes of leadership – those that have low levels of control and regulation – were positively related to explorative and exploitative KM processes in a global software company in India. Other styles have been found to be significantly linked to knowledge sharing, such as ''initiating structure'' and ''consideration''[2] leadership styles (Huang *et al.*, 2008). von Krogh *et al.* (2011) also include the role-modelling or ''leading by example'' as a leadership style for KM since it describes a specific form of behavior based on the adoption of knowledge practices, the encouragement of followers to pursue an initiative, and support for their efforts (e.g. Rosenbloom, 2000; DeTienne *et al.*, 2004).

An important branch within the style theory differentiates between transactional and transformational leadership (Burns, 1978). In general, these studies find transformational leadership to be more preferable to KM than transactional[3]. Certain empirical studies establish that transformational leaders promote innovation and foster knowledge creation in a more intensive manner than transactional leaders (Crawford and Strohkirch, 2002; Crawford *et al.*, 2003). Politis (2001) also analyzed the relationship between elements of both leadership styles and knowledge acquisition in organizations and found that the transformational leadership style is the most strongly related to this knowledge process. Similarly, Bryant (2003) argued that there is a clear relationship between KM and transformational leadership in organizations. In addition, conditions of transformational leadership have been highlighted by certain studies in order to promote autonomy, commitment and trust for improving KM processes such as empowerment. For instance, Srivastava *et al.* (2006) showed that empowerment is positively related to team efficacy and knowledge sharing and plays a mediating role in relation to performance. Gagne (2009) also shows that empowerment (and transformational leadership) is related to the followers' needs for competence and autonomy, which are essential conditions for effective knowledge creation and innovation.

Prescriptive theory for leadership action states that one specific style may not be the most appropriate approach, and focuses on broader prescriptions for leadership actions (von Krogh *et al.*, 2011, p. 8). For instance, Ho (2009) emphasizes the role of leaders as facilitators of KM by planning knowledge processes. Others point out that leaders can impact organizational effectiveness by formulating strategy, vision and mission, and fostering organizational culture; this strategic leadership includes the processes by which top managers make strategic decisions within organizations (Reinmoeller, 2004).

Taking the view that a leadership for KM comprehends a mix of several theoretical elements among which style, strategic and role-modeling leadership should be included, in this study a knowledge-oriented leadership is characterized as a main facilitator of knowledge exploration and exploitation practices. For example, Rosen *et al.* (2007) understand leadership tasks as the role-modeling (leading by example), articulation of a vision, clarification of leaders' expectations of their followers, recognition, and rewards; and Pan and Scarbrough (1999) included role-modeling, support of the organizational culture, creation of a managerial mindset towards KM, and developing an environment conducive to

knowledge creation and sharing. In general, these tasks describe transformational leaders, whose style has been found to be positively related to knowledge exploration activities (e.g. Politis, 2001; Crawford *et al.*, 2003; Singh, 2008; Gagne, 2009) as well as exploitative (e.g. Srivastava *et al.*, 2006; Yang, 2007; Singh, 2008).

Based on the results of these studies, in this paper it is proposed that when a knowledge-oriented leadership based on the promotion of trust and learning, and empowerment of followers is developed, the usage of KM practices will be encouraged and their performance, in terms of innovation, improved. That is, leadership will favor the interaction of people, knowledge sharing and increased experimentation – all which it is at the core of knowledge exploration activities for innovation – and propel greater willingness to transfer, codify and apply knowledge – knowledge exploitation – for further innovation. The following hypotheses are thus established:

H3. The greater the orientation of the firm towards a knowledge-oriented leadership, the higher the level of influence of knowledge exploration practices on innovation results.

H4. The greater the orientation of the firm towards a knowledge-oriented leadership, the higher the level of influence of knowledge exploitation practices on innovation results

Knowledge-centered HR practices, KM and innovation

HR management concerns the policies, practices and systems that a company can use to influence employees behavior, attitude and performance (Gloet and Berrell, 2003: 83). Access to knowledge along with its generation and application are challenges that demand the development of HR initiatives that motivate and endeavor to get employees to become involved in KM projects (Alavi and Leidner, 2001; Cabrera and Cabrera, 2005).

In general, work on the relationship between KM and HR practices is focused on the consideration of general conditions developed by the firm – through HR management – for knowledge exploration and/or exploitation processes to be more effectively carried out. A branch of studies are centered on HR configurations that fit to specific KM strategies, which mostly are characterized as being humanistic – based on the use of tacit knowledge – or IT oriented –based on the use of explicit knowledge. While an IT approach to KM implies HR management (e.g. training, involvement, recognition) to be oriented toward the promotion of the IT usage for managing explicit knowledge, the humanist perspective is basically focused on creating a suitable environment for knowledge sharing (Gloet and Berrell, 2003; Mehta, 2008). An integration of the two approaches also is demanded by a number of authors (e.g. >Soliman and Spooner, 2000; Gloet and Berrell, 2003; Haesli and Boxall, 2005).

For instance, Haesli and Boxall (2005) examined two configurations (fits) between KM and HR strategies, codification-recruitment and personalization-retention. The first one is based on IT solutions, which implies the codification of knowledge and it is used to capture and utilize explicit knowledge. The second configuration derives from HR solutions, which relies on organizational learning and the implementation of HR management strategies to capture and utilize tacit knowledge. Overall, they suggest that although the adjustment of HR and KM strategies seems to improve organizational performance, both approaches should be seen as complementary rather than exclusive. Edvardsson (2008) also studied two different approaches to HR management strategies –explorative and exploitative– and the resulting impact on KM. While the exploitative strategy tends to place a greater emphasis on IT solutions to KM, the explorative focuses on tacit knowledge, which results in further innovation, organizational learning and knowledge transfer. The conclusion, yet again, is that both approaches should be complementary, even more so when firms tend to develop ambidexterity strategies (e.g. high levels of exploration and exploitation/codification and personalization).

The second strand of studies focuses on the study of HR practices as facilitators of KM processes. In this process-based perspective, HR management is the infrastructure used

by a firm to support KM activities (Gold *et al.*, 2001). As achieving a competitive advantage from a knowledge-based view depends on the firm's ability to create and exploit knowledge – better than other firms – it could be inferred that HR practices can contribute to this end by supporting KM processes in a number of ways. For instance, firms could create an environment that was conducive to knowledge exploration or exploitation by using practices such as teamwork, the promotion of positive attitudes towards knowledge sharing, socialization programs, team performance appraisal or compensation and reward systems (Cabrera and Cabrera, 2005; Brewer and Brewer, 2010). In this stream of research, Currie and Kerrin (2003) studied barriers based on functional subcultures for knowledge sharing in a case study of a global pharmaceutical company. In conclusion, they emphasize the role of HR practices such as the lateral career progression accompanied by teamwork to overcome those cultural barriers for knowledge-sharing improvement. Similarly, Arthur and Kim (2005) analyzed conditions that could facilitate employees to share high-value knowledge. Their results showed that the promotion of cooperation and management support made employees more willing to submit higher risk ideas that, in turn, improved productivity levels of the corporation.

Overall, studies from both branches suggest positive interactions between KM activities and HR practices. From this viewpoint this paper proposes, in addition to culture and leadership, a moderating role of knowledge-oriented HR practices in the relationship between KM and innovation outcomes. In a similar vein, Chen and Huang (2009) studied the mediating effect of knowledge management capacity – knowledge acquisition, transfer and application – in the relationship between certain strategic HR practices – training, compensation, performance appraisal, selection and participation – and innovation performance (technical and administrative), and they found that this effect was positive and significant.

Similarly to Laursen and Mahnke (2001) and Cabrera and Cabrera (2005), in this study knowledge-centered HR practices are considered as those which contribute to develop an environment that allows the firm to take advantage of knowledge exploration and exploration initiatives, such as ''interdisciplinary teamwork'', ''planned job rotation'', ''collection of employee proposals'', ''delegation of responsibility'', ''performance related pay'', ''internal and external company training''. These HR practices will favor the interaction of people and ideas, the sharing of knowledge, and greater willingness to codify, transfer and apply knowledge.

Considering the existing relationships between HR and KM, a multiplying effect of general knowledge-centered HR practices on KM is suggested in this study, which will result in a higher level of innovation outcomes. Regarding KM activities, both exploration and exploitation have been associated with innovation and organizational improvements in various studies (e.g. Helfat and Raubitschek, 2000; Bierly and Daly, 2002; Miller *et al.*, 2007; Zack *et al.*, 2009) but the effects of interactions with HR practices for innovation may be somehow different, as Chen and Huang (2009) show in their study by differentiating knowledge acquisition from exploitation. The following hypotheses are thus proposed:

H5. The greater the orientation of the firm towards knowledge-centered HR practices, the higher the level of influence of knowledge exploration activities on its innovation results.

H6. The greater the orientation of the firm towards knowledge-centered HR practices, the higher the level of influence of knowledge exploitation activities on its innovation results.

3. Research methodology

Population, sample and data collection

For this study a survey methodology was used in order to gather primary data for the empirical analysis. Technological firms were selected for the research since these kinds of companies are quite sensitive to the use of both exploration and exploitation practices (He and Wong, 2004), and innovation plays a pivotal role in their competitive advantage

(Grant, 2002; Jansen *et al.*, 2006). The selection of these companies is also justified by a number of studies on knowledge management and innovation that have utilized high-tech or innovative industries for empirical testing. Different examples are the studies of Bierly and Chakrabarti (1996) or Currie and Kerrin (2003) in the pharmaceutical industry; Hansen *et al.* (1999) in consulting services; He and Wong (2004) in innovative firms based on OECD classifications; or recently Singh (2008) and Mehta (2008) in global software companies.

The study's population included industrial companies from four innovative industries of the Spanish industrial classification CNAE-93. These four industries are included in a section (DL) classified as ''manufacturing of electric, electronic and optical material and equipment''[4]. On the one hand, the reason to focus on industrial firms was based on the more simple delineation for product and process innovations in that setting than in service activities. On the other hand, the INE (National Statistics Institute of Spain) classifies these industries as technology-intensive. In addition, these industries guaranteed the provision of an important number of companies to apply multivariate statistical techniques for which the sample size is an essential issue. Finally, in order to have minimum dimensioned firms, only those with more than 25 employees were incorporated into the population, which finally included 802 firms with 54.3 percent belonging to the electrical materials and equipment industry; 25.6 percent to the electronic material industry; 3.4 percent to the office equipment industry; and 16.7 percent making up the medical, surgical and optical material industry.

After collecting data and information from companies and establishing an *ad-hoc* database[5] a postal survey was conducted. A questionnaire including questions referred to knowledge management, innovation, and strategy was sent to firms, requesting that it be completed by top executives who were familiar with the topic of this study (KM and innovation). Certain questions were open (e.g. number of new products obtained over the last three years) but most of them were seven-point scales ranging from 1 (''strongly disagree''/''very low'') to 7 (''strongly agree''/''very high''). The questionnaire was designed and developed on the basis of a thorough literature review. Before sending the questionnaires, a pretest was applied, for which personal interviews with three top executives of technology-intensive companies and several academics were made. These interviews allowed the authors to improve the quality of some of the questions and correct deficiencies in wording and meaning.

After sending out the questionnaire (a second mailing was made one month later than the first one, in May 2004) a total of 111 usable questionnaires were received back, representing 13.84 percent of the response rate. The responding firms had an average age of 33.59 years (SD = 13.79) and an average size (measured by the number of employees) of 275.27 (SD = 65.20). To test for non-response bias, differences in certain variables between respondents and non-respondents were examined in our final sample. *T*-tests did not show significant differences between them in relation to size ($t = 0.705$; $p < 0.91$) or age ($t = 0.927$; $p < 0.74$). No significant differences were found either regarding the distribution of the sample by industries in comparison to the study's population – electrical materials and equipment industry 48.7 percent; electronic material and equipment industry 26.1 percent; office equipment industry 6.3 percent; and medical, surgical and optical material 18.9 percent.

Finally, the Harman one-factor test was applied to examine the potential problem of common method variance. Problems would arise if one general factor accounts for the majority of covariance in the variables (Podsakoff and Organ, 1986). A principal factor analysis (principal components and varimax rotation) on the questionnaire measurement items of this study yields six factors with eigenvalues greater than one that account for 67.807 percent of total variance, with the first factor accounting for 20.711 percent. A single factor does not emerge and one general factor does not account for the majority of the variance, so common method bias is unlikely to be a serious problem in the data (Podsakoff and Organ, 1986).

Measures

Knowledge exploration and exploitation practices. To date, multi-indicator measures for exploitation and exploration constructs have not been generally accepted in KM literature (Gupta *et al.*, 2006; Miller *et al.*, 2007: 415)[6]. For this reason, related literatures were explored – i.e. innovation strategy – for an indicator. Exploration practices are considered in this study as the effort made by a firm to internally develop its knowledge base, for which an index designed by Zahra and Das (1993) and improved by Zahra and Bogner (1999) that comprises four items was adapted and used, each item ranging from 1 (strongly agree) to 7 (strongly disagree) (see Appendix). For instance, one item was ''over the last three years, there has been a strong commitment in my company (for example, to training, in equipment) to depend on internal R&D activities to develop or improve technologies (products, processes)''. To assess the internal consistency reliability, the well-known Cronbach's alpha was applied, showing a high value ($\alpha = 0.927$). In order to check convergent and discriminant validity of the measure, the average variance extracted (AVE) was used as Hair *et al.* (1998) recommend. The AVE value for knowledge exploration was 0.822, whereas the threshold for acceptable convergent validity is 0.5 (Fornell and Larcker, 1981). The discriminant validity was checked by examining the square root of the AVE. Since this figure is greater than the correlations between all other constructs (0.906), it suggests that the items were reasonably well measured (Fornell and Larcker, 1981).

On the other hand, a multi-item measure was also built in order to collect knowledge exploitation practices as carried out by previous research, including storage, transfer and application practices (see Appendix). Eleven items were taken and adapted from the previous studies of Davenport *et al.* (1998), O'Dell and Grayson (1998), Alavi and Leidner (2001), Bontis *et al.* (2002), Alavi and Tiwana (2003), Gold *et al.* (2001) and Wang and Ahmed (2004). One example is ''over the last three years in our company, it has been possible to access knowledge repositories, databases and documents through some kind of internal computer network (such as an intranet or similar)''. Items ranged from 1 (''strongly disagree'') to 7 (''strongly agree''). Reliability was checked through Cronbach alpha, which offered a high value ($\alpha = 0.904$). For the analysis of convergent and discriminant validity, the AVE of this measure was 0.5127, which it is above the threshold of the recommended figure of 0.5, and the square root was 0.715, greater than the correlations between all other constructs.

Finally, as the consideration of knowledge exploration and exploitation as two different constructs has been largely emphasized in this study, an exploratory factor analysis – using varimax rotation with principal components – was applied in order to additionally check the dimensionality of both measures. As Table I shows, two different factors emerged with eigenvalues greater than one, with items being grouped as expected.

Knowledge-centered culture. Following Alavi *et al.* (2005, p. 195), culture is conceptualized in this paper in terms of values that should support and promote KM activities[7]. The KM literature was carefully checked to establish a measure of a knowledge-centered culture for promoting KM. A multi-item indicator was built comprising seven items, trying to include values such as the encouragement of experimentation and tolerance of mistakes for knowledge sharing (DeTienne and Jackson, 2001), the promotion of trust, confidence and openness (Gold *et al.*, 2001; Lee and Choi, 2003), a sense of a common intention for all organizational members (Jarvenpaa and Staples, 2003), empowerment through an emphasis on responsible behavior (Lee and Cole, 2003) or the development of a common organizational language, which enables effective communication among employees, units and departments (Nonaka and Takeuchi, 1995; Grant, 1996). All the items were established as seven-point scales with 1 meaning ''strongly disagree'' and 7 ''strongly agree''. One representative was ''over the last three years in this company, we have tried to encourage employees to experiment and implement new ideas in their working day''.

The Cronbach's alpha of this measure offers an acceptable value ($\alpha = 0.898$; seven items) regarding internal reliability. In relation to convergent validity, the AVE of the measure is 0.623 (greater than the threshold 0.5). In relation to discriminant validity, the square root of the AVE

Table I Exploratory Factor analysis: knowledge exploration and exploitation practices

*Variables**	*Factor 1: Exploitation*	*Factor 2: Exploration*	*Communalities*
Exploration1	0.002	*0.929*	0.864
Exploration2	0.151	*0.932*	0.892
Exploration3	0.199	*0.827*	0.724
Exploration4	0.107	*0.881*	0.787
Exploitation1	*0.569*	−0.153	0.447
Exploitation2	*0.617*	−0.025	0.482
Exploitation3	*0.634*	0.147	0.424
Exploitation4	*0.729*	0.179	0.563
Exploitation5	*0.831*	0.088	0.698
Exploitation6	*0.735*	0.176	0.571
Exploitation7	*0.707*	0.283	0.579
Exploitation8	*0.851*	0.015	0.725
Exploitation9	*0.727*	0.174	0.559
Exploitation10	*0.603*	0.401	0.524
Exploitation11	*0.688*	0.218	0.521
% Explained variance	36.884	24.180	Total = 61.064

Notes: *See Appendix; Total explained variance = 61.064; Kaiser-Meyer-Olkin test = 0.862; Barlett's sphericity test χ^2= 1061.196; significant = 0.000; Figures in italic are factor loadings which are the highest for each of the two extracted figures

is 0.789, which is greater than the correlations with all the other constructs. These results suggest that the items were reasonably well measured.

Knowledge-oriented leadership. Knowledge-oriented leadership was measured through a seven-point scale with six items generated after carefully examining KM and leadership literatures. Basically, the items refers to a transformational style of leadership, although an item referred to the promotion of the use of IT through rewards may be understood as being linked to a more transactional style (von Krogh *et al.*, 2011). Among the items included in the indicator are conditions to promote responsible behaviors of employees and teams (Rosenbloom, 2000), the role of leaders as mediators for sharing and application of knowledge (Nonaka and Takeuchi, 1995; Spender, 1996; Pan and Scarbrough, 1999), their role for evaluating employees on the basis of tolerating errors and promoting learning rather than work results (Bollinger and Smith, 2001; Roth, 2003), the generation of expectations regarding the quality of work of employees trying to promote creativity (Roth, 2003; Haas and Hansen, 2005), leading by example by assuming the role of knowledge managers (Bryant, 2003; Reinmoeller, 2004), or rewarding employees who share and apply knowledge (Pan and Scarbrough, 1999). One representative is ''managers are accustomed to assuming their role of knowledge leaders, which it is mainly characterized by openness, tolerance of mistakes and mediation for the achievement of the firm's objectives''. Items ranged from 1 ''totally disagree'' to 7 ''totally agree''.

The reliability test shows a high value for this measure ($\alpha = 0.900$). The AVE of the indicator is 0.675, and the square root is 0.821. These results suggest that the items were reasonably well measured showing internal consistency as well as both convergent and discriminant validity.

Knowledge-centered HR practices. A multi-item measure based on KM and HR literatures was designed to capture the knowledge-centered HR practices construct (see Appendix). At the time of developing the questionnaire (2004) only partial analyses of specific HR practices on KM processes had been carried out (see, e.g. Currie and Kerrin, 2003; Hatch and Dyer, 2004) and global indicators on knowledge-oriented HR practices did not exist, with the exception of the collection of HR practices for innovative KM strategies offered by Laursen and Mahnke (2001). Based on the studies of Davenport *et al.* (1998), Soliman and Spooner (2000) and Laursen and Mahnke (2001) we built an indicator comprising six items, which included rewards based on team performance, training, promotion of teamwork, performance appraisal based on knowledge sharing results, and participative mechanisms to solve problems (see Appendix for more details). These items are very similar to those

used by Chen and Huang (2009) to test mediating effects of KM processes in the relationship between strategic HR practices and innovation performance. One representative is ''over the last three years, the company has developed programs of internal rotation, which make the employees pass through different departments or develop diverse functions''. The items ranged from 1 (''strongly disagree'') to 7 (''strongly agree'').

Regarding internal consistency reliability of the measure, the Cronbach's alpha shows an acceptable value ($\alpha = 0.810$; six items). The value of AVE is 0.520 (above 0.5), and the square root is 0.721 (greater than the correlations between all other constructs). These analyses show acceptable measures for both convergent and discriminant validity.

Innovation results. In the last few years, innovation has been frequently used as an organizational performance measure in studies on KM (e.g. Youndt and Snell, 2004; Subramaniam and Youndt, 2005; Chen and Huang, 2009; Donate and Guadamillas, 2010). For this study, a measure was built, which included items referred to new process and product technologies along with improvements in these during the last year for the firm. The compound measure is justified by the fact that we do not focus on dichotomies such as type (products or processes) or grade (radical or incremental) but generally on the level of technological innovation achieved by a company. Eight items were selected based on the literature on innovation strategy, specifically adapted from the measures developed by Zahra and Das (1993) and Zahra and Bogner (1999). These measures include, apart from absolute subjective items (level of results of the company), relative items (level of results compared to those of the relevant competitors), which following Zahra and Das (1993, p. 24) is a necessary requirement as innovation effectiveness strongly depends on the comparison with other magnitudes (e.g. rivals' performance; results achieved various years ago). Some examples are ''assessment of the results referred to new production methods and procedures obtained during the last year'' or ''assessment of the results referred to the introduction of more new (or improved) products than major competitors during the last year'', with items ranging from 1 ('' very low) to 7 (''very high'').

The arithmetic mean for the eight items was calculated to be used as a dependent variable in subsequent analyses. The internal consistency of the measure is shown as acceptable ($\alpha = 0.896$). In addition, the AVE of the measure is 0.582 (above 0.5), and the square root of the AVE is 0.762 (above the correlations with the rest of constructs), which seem to be reasonable figures for both discriminant and convergent validity.

Control variables. In this study, various relevant variables were included in order to control for possible confounding effects on dependent variables. In general, size, age, industry and R&D spending have been utilized as control variables in studies including KM practices and innovation. Regarding size, it is likely that the most sizable firms invest a greater amount of their budgets in innovation, KM tools and other initiatives based on HR management than small companies, which could importantly affect innovative outcomes. In addition, larger units also may have more resources yet may lack the flexibility to develop knowledge exploration instead of exploitation practices, which might affect innovation performance (Subramaniam and Youndt, 2005; Jansen *et al.*, 2006). Age might also influence innovation outcomes as companies may exhibit organizational characteristics and resource deployment (Chen and Huang, 2009). In relation to industry inclusion, in terms of attractiveness, certain industries could be in a better position than others depending on their internal structure and existing innovation opportunities (Porter, 1980). Although innovative industries were selected for this study, the authors controlled for differences in innovation results following the example of He and Wong (2004), who controlled five broad industries – although firms of their sample were all considered as innovative. Finally, R&D spending was used as a control variable since firms spending more on R&D are more likely to achieve better results in terms of new technologies, as the innovation strategy literature shows in numerous studies (e.g. Zahra and Das, 1993; Zahra, 1996; Zahra and Bogner, 1999).

In order to measure company age, the natural log of number of years from foundation was used, while size was measured through the number of employees figure, with the 1/X

function used to compensate for skewness. Industry controls were made operational by establishing three dummy variables (with one of the industries as the reference). An indicator of four items built by Zahra and Das (1993) was used to capture the R&D spending construct (see Appendix), showing high reliability ($\alpha = 0.925$, four items). Its AVE was 0.732 (greater than 0.5) and the square root was 0.855 (greater than correlations with the rest of the constructs), which are acceptable figures for both convergent and discriminant validity.

4. Empirical analysis and results

A correlation matrix of all variables is shown in Table II, along with means, standard deviations, and the square root of AVE for latent variables (main diagonal)[8]. Previously, the requirements of normality were analyzed through the examination of histograms and the application of the Kolmogorov-Smirnov test, which yield acceptable values for almost all the variables. In the cases where normality was not achieved, a transformation for the variable was carried out (e.g. size or firm's age). This study also used variance inflation factors (VIFs) to examine the effect of multicolinearity. The values of the VIF associated with the predictors show a range from 1.09 to 4.30, which fall within acceptable limits – below the rule-of-thumb cut-off of 10 (Neter *et al.*, 1990; Hair *et al.*, 1998).

In order to test the hypotheses of this study, a hierarchical multiple regression analysis was applied (Tables III and IV). Previously, research variables were centered as Hair *et al.* (1998) recommend with the aim of avoiding statistical problems as much as possible (e.g. multicolinearity). In total, six models were built to test the hypotheses. The first model only included the control variables; in the second model, the exploration and exploitation variables were added; in the third model, the rest of the independent variables were included; and finally in the fourth, fifth and sixth models, the interactions corresponding to exploration and exploitation with regard to knowledge-centered culture, knowledge-oriented leadership and knowledge-centered HR practices were added respectively.

In Tables III and IV, all the models are found significant although with different implications. Model 1 is significant (adjusted $R^2 = 31.2$) mainly due to the strong influence of the R&D spending variable (significant with $p < 0.01$) on the innovation results. The second model is also significant with the inclusion of knowledge exploration and exploitation practices, all of which explains 45.3 percent of the variance of the innovation results. Moreover, and as expected, coefficients for both knowledge exploration and exploitation practices are positive and significant (with $p < 0.01$), meaning that they are directly related to innovation results (although the effect is bigger for exploration than exploitation). In other words, the higher the development of knowledge exploration and exploitation practices, the higher the innovation outcomes.

The third model in which knowledge-centered culture, knowledge-oriented leadership and knowledge-oriented HR practices were included as independent variables is also significant and it improves the former model, although individual variables are not all significant. From these three variables, only leadership shows a direct significant relationship (although the level of significance is not too high, $p < 0.1$) on innovation outcomes. This result therefore suggests that culture and HR practices do not have significant influence on innovation results on their own, reinforcing the idea of being considered as support elements for exploration or exploitation practices rather than independent aspects in order to achieve further innovation, as certain studies suggest (Janz and Prasarnphanic, 2003; Alavi *et al.*, 2005).

The three subsequent models (4, 5 and 6) in which interactions were included are all significant, improving the previous model. For knowledge-centered culture and leadership, it is found that both variables improve the effect of KM practices – exploration and exploitation – on innovation results, which supports *H1-H4*. Regarding HR practices, *H5* is not supported (although the level of significance is close to being below 10 percent) while *H6* is supported since the interaction between exploitation and HR practices is found to be positive and significant. Consequently, exploration is not significantly influenced by HR practices in order to achieve further innovation while they have a moderating effect in the relationship between knowledge exploitation and innovation outcomes.

Table II Means, standard deviations and correlations

		Mean	*SD*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
1.	Exploration	5.11	1,55	(0.90)										
2.	Exploitation	4.59	1,21	0.28	(0.70)									
3.	Culture	5.03	1,12	0.38	0.52	(0.78)								
4.	Leadership	5.05	1,18	0.35	0.50	0.63	(0.82)							
5.	HR practices	4.54	1,14	0.26	0.63	0.59	0.58	(0.72)						
6.	Innovation results	5.24	0.95	0.65	0.40	0.46	0.51	0.44	(0.76)					
7.	R&D spending	4.54	1.42	0.61	0.36	0.46	0.43	0.43	0.57	(0.85)				
8.	Industry (1)	0.49	0.50	−0.01	−0.002	−0.01	0.008	0.04	0.08	−0.02				
9.	Industry (2)	0.26	0.44	0.01	0.11	0.07	0.08	0.05	0.003	0.04	0.57			
10.	Industry (3)	0.19	0.39	−0.08	−0.14	−0.12	−0.14	−0.14	−0.17	−0.09	0.47	0.28		
11.	Size	0.10	0.05	−0.20	−0.20	0.01	0.02	−0.12	−0.16	−0.25	0.05	0.01	0.02	
12.	Age	3.27	0.74	0.00	−0.07	−0.17	−0.09	−0.19	−0.07	−0.04	0.12	0.20	0.16	0.19

Notes: n=111 (two-tailed test. Correlations with absolute value greater than 0.19 are significant at $p < 0.05$, and those greater than 0.25 are significant at $p < 0.01$; The square roots of the AVE for the multi-item indicators are shown on the diagonal in parentheses; Industry (1): inclusion in group 31 (group 30 as reference). Dummy variable; Industry (2): inclusion in group 32 (group 30 as reference). Dummy variable; Industry (3): inclusion in group 33 (group 30 as reference). Dummy variable

Table III Multiple regression analysis

Variables	*Model 1*		*Model 2*		*Model 3*	
	St. coeff.	t-*value*	*St. coeff.*	t-*value*	*St. coeff.*	t-*value*
Constant	0.370	0.772	0.320	0.747	0.382	.886
Size	−0.043	−0.511	−0.018	−0.234	−0.079	−0.992
Age	−0.056	−0.659	−0.066	−0.862	−0.060	−0.776
Industry (1)	0.032	0.186	0.049	0.318	0.067	0.447
Industry (2)	−0.047	−0.303	−0.038	−0.271	−0.014	−0.100
Industry (3)	−0.107	−0.723	−0.069	−0.523	−0.046	−0.355
R&D spending	0.553	6.681***	0.032	0.252	−0.061	−0.461
Exploration			0.554	4.568***	0.571	4.638***
Exploitation			0.224	2.892***	0.005	0.046
K-C culture					−0.038	−0.272
K-O leadership					0.282	1.848*
K-C HR practices					0.088	0.658
F	9.311***		12.410***		13.388***	
(%) R^2	34.9		49.3		53.6	
(%) Adjusted R^2	31.2		45.3		48.4	
(%) Increase in R^2	34.9		14.4		4.3	
Change in *F*	9.311***		14.47***		3.025**	

Notes: Dependent variable: Innovation results; *Significant $p < 0.1$; **Significant $p < 0.05$; ***Significant $p < 0.01$

Table IV Multiple regression analysis

Variables	*Model 4*		*Model 5*		*Model 6*	
	St. coeff.	t-*value*	*St. coeff.*	t-*value*	*St. coeff.*	t-*value*
Constant	0.362	0.833	0.343	0.779	0.207	0.469
Size	−0.080	−1.050	−0.089	−1.144	−0.082	−1.071
Age	−0.052	−0.653	−0.048	−0.605	−0.023	−0.287
Industry (1)	0.025	0.174	0.049	0.329	0.031	0.212
Industry (2)	−0.063	−0.477	−0.055	−0.412	−0.055	−0.418
Industry (3)	−0.076	−0.607	−0.052	−0.413	−0.074	−0.584
R&D spending	−0.065	−0.510	−0.064	−0.495	−0.038	−0.296
Exploration	0.542	4.515***	0.566	4.690***	0.547	4.563
Exploitation	0.048	0.419	0.012	0.103	0.016	0.142
K-C culture	0.055	0.396	0.049	0.352	0.037	0.266
K-O leadership	0.226	1.531	0.193	1.236	0.243	1.630
K-O HR practices	0.086	0.664	0.112	0.850	0.093	0.717
Exploration*Culture	0.150	1.968**				−1.556
Exploitation*Culture	0.230	2.925***				2.780
Exploration*Leadership			0.178	2.053**		
Exploitation*Leadership			0.202	2.374**		
Exploration*HR pract.					0.116	1.556
Exploitation*HR pract.					0.215	2.780***
F	10.304***		9.746***		10.040***	
(%) R^2	58.0		56.6		57.4	
(%) Adjusted R^2	52.4		50.8		51.7	
(%) Increase in R^2	4.4		3.1		3.8	
Change in *F*	5.105***		3.42**		4.307**	

Notes: Dependent variable: Innovation results; *Significant $p < 0.1$; **Significant $p < 0.05$; ***Significant $p < 0.01$

5. Discussion and conclusions

This study provides new evidence that organizational culture, leadership and HR practices moderate the effect of KM practices on the innovation results of the firm, which offers a comprehensive understanding of knowledge exploration and exploitation initiatives connected to innovation and their interrelations with certain organizational factors. In line with previous studies, this paper adds one more piece of evidence by stating that, from innovation and knowledge-based view perspectives, organizational conditions are essential

for both knowledge exploration and exploitation activities (Bierly and Daly, 2002; DeTienne *et al.*, 2004; Miller *et al.*, 2007; Ho, 2009). This study also contributes to the theoretical development of a conceptual model for explaining relationships among KM practices, organizational human-based factors and innovation performance. Few studies in the literature examine these relationships and this deficiency is quite serious owing to the increasing importance of innovation for firms (Chen and Huang, 2009).

Research on exploration and exploration practices and the antecedents and consequences of both activities still remains unclear (Jansen *et al.*, 2006: 1669). In line with this statement, this study is mainly an attempt to empirically analyze the effect of three organizational factors – culture, leadership, and HR practices – in the relationship between both types of practices and an organizational performance measure, the innovation outcomes. In so doing, our study departs from previous works that assert that exploration or exploitation practices (as a whole or as individual processes such as knowledge creation, sharing or application) are influenced by knowledge-oriented organizational values (e.g. Lee and Cole, 2003; Alavi *et al.*, 2005; Donate and Guadamillas, 2010), the way leaders manage KM processes (e.g. Roth, 2003; Yang, 2007; von Krogh *et al.*, 2011) or knowledge-centered HR practices (e.g. Cabrera and Cabrera, 2005; Edvardsson, 2008; Brewer and Brewer, 2010). Other studies also assert that organizational factors are essential elements in order to make implementation of KM strategies easier (e.g. Earl, 2001; DeTienne *et al.*, 2004; Garavelli *et al.*, 2004; Zack *et al.*, 2009).

From the empirical test, it has been found that both exploration and exploitation have a positive and significant effect on innovation results, in line with the existing empirical research (e.g. He and Wong, 2004; Miller *et al.*, 2007; Chen and Huang, 2009; Zack *et al.*, 2009). Although certain researchers associate the term exploitation with activities in which the central goal is using past knowledge, ruling out the possibility of linking exploitative activities with learning and innovation (e.g. Rosenkopf and Nerkar, 2001; Vassolo *et al.*, 2004), in this study it has been found that the use of practices for knowledge storage, transfer and application relates positively to innovation performance, in line with a wide stream of research of the knowledge-based view (e.g. Bierly and Daly; He and Wong, 2004; Gupta *et al.*, 2006; Chen and Huang, 2009). In this sense, this finding is related to the research of Gupta *et al.* (2006) in regard to the conceptualization of innovation success as a mixture of exploration and exploitation processes, and is also related to the March's (1991, p. 85) assertion on the presence of learning in both processes, although of a different type: ''the essence of exploitation is the refinement and extension of existing competencies, technologies and paradigms [. . .] the essence of exploration is experimentation with new alternatives''. As the results of this study show, and Gupta *et al.* (2006) pointed out, it is thus more logical to differentiate between exploration and exploitation regarding the amount (or type) of innovation rather than in the presence or absence of learning and innovation.

Regarding the organizational factors included in model 3, the individual coefficients of culture and HR practices are not significant, but the coefficient for the leadership variable is positive and significant. On this point, it is important to highlight the relationship among culture, HR practices and leadership. As von Krogh *et al.* (2011) point out, leaders play a crucial role in establishing organizational conditions and infrastructure that enhances and facilitates KM. They have to implement HR practices like training and empowerment to promote KM (Bollinger and Smith, 2001) and are also responsible of building and maintaining an organizational culture that advocate the importance of KM focused in organization resources (Davenport and Prusak, 1998). Thus leadership seems to be an important antecedent for culture implementation and HR practices style, and thus it could explain the significance of this variable against the others, which it is highly consistent with previous research (Politis, 2001; Johnson, 2002; Bryant, 2003). Undoubtedly, future research in this area will be necessary in order to elucidate these relationships and effects on innovation.

In model 3, it is also important to highlight that exploitation practices lose importance in terms of their relationship to innovation performance when organizational factors are included in the regression equation. Although variables have been centered trying to avoid

collinearity, and the VIF values are acceptable (under the threshold of 10), it is likely that the exploitation parameter's estimation has been affected by the existing correlations with the organizational factors and therefore does not significantly relate to innovation results. Another explanation could be based on the existing relationships between exploitation practices and organizational factors in order to explain innovation results. In contrast to exploration – which is significant both in models 2 and 3 –, in the case of exploitation, the model might be misspecified if other additional variables are not included – i.e. leadership, culture and HR practices –, and the effects on innovation results would only be shown when interactions were considered.

H1-H4 has been supported by the empirical test. When interactions corresponding to multiplying effects between knowledge exploration and exploration practices and culture and leadership, respectively, were added, the models (and increases in R^2 for those models) were all significant. As hypothesized, the moderating effects of culture and leadership are positive and significant, which it means that innovation results improve as a consequence of these interactions (as compared with the effect of all the independent variables in isolation, i.e. model 3). In respect of culture, as previous studies suggest, knowledge-friendly organizational values can be considered as major catalysts for knowledge processes in the firm oriented to innovation (Gold *et al.*, 2001; Alavi *et al.*, 2005). Moreover, this result confirms findings of empirical studies that show the way and strength with which organizational culture influences knowledge processes in a strategy implementation context (Palanisamy, 2008). On the other hand, leadership is an essential condition in order that KM efforts can be totally exploited (von Krogh *et al.*, 2011). It is an element that directly propels KM processes by establishing rules, building an appropriate context to share knowledge, and developing a culture for KM in the firm (Garavelli *et al.*, 2004). Hence it influences both exploration and exploitation activities, and in doing so, enhances the innovation outcomes for the firm, as tested in this study.

Finally, two different results have been found with regards to HR practices. While *H6* has been supported, contrary to the authors' prediction *H5* has not, meaning that there is not a moderating effect of this variable in the relationship between exploration practices and innovation. Maybe this could be explained by the fact that in order to achieve further innovation, exploration can need other different HR practices than those that are used regarding endeavors made in reference to exploitation, which is more sensitive to general, knowledge-oriented practices designed to create a supporting environment for knowledge flows (Miller *et al.*, 2007). To establish the hypotheses, the authors have implicitly followed the assumption than even though there are difficulties for firms in simultaneously pursuing exploration and exploitation, there exist certain organizational conditions that support both, such as team-based work, a common language, or HR practices that promote creativity and experimentation (Bierly and Daly, 2002). In this sense, although culture and leadership as established in this study seem to support both exploration and exploitation in the quest for further innovation, HR practices should be designed specifically to push exploration activities in a different manner. It is likely that while culture and leadership can be established in a broader sense and affect both types of activities, HR practices should be more specifically adapted to exploration initiatives. For instance, it is likely that compensation, training or team motivation have to be designed in a specific way as R&D teams may work more independently than the rest of firm's functional areas. Additional research about this point is also necessary to carry out in future studies.

The findings of this paper have important implications for managerial practices. This study establishes that the successful implementation of KM oriented to innovation in organizations requires specific tools and practices for enhancing knowledge exploration and exploitation, but that this also needs coherent cultural values and HR practices while leadership should be considered as a key enabler in this process. Managers should care about knowledge strategy formulation but also help to develop organizational aspects based on human factors for encouraging the optimal utilization of KM practices. The role of managers in promoting knowledge-centered cultural values, propelling knowledge-oriented HR practices and leading by example to encourage knowledge creation, codification, transfer

and application is thus vital for firms. By creating an internal environment to encourage knowledge exploration and exploitation, firms are providing their members with ''organizational high-order principles'' to achieve further learning and innovation (Kogut and Zander, 1992). Managers should not only be aware of the importance of developing KM initiatives for innovation but they should also consider that human resources have to be pushed in the (correct) use of KM tools and participation in KM initiatives.

The following may be considered to be limitations of this paper. First, the research design of this study is cross-sectional and although the results are consistent with theoretical reasoning, it may not rule out causality concerning the hypothesized relationships. Future research might address this issue by using longitudinal design in drawing causal inferences. Second, common organizational elements for both exploration and exploitation practices have been analyzed, but specific conditions may be necessary in order to fully exploit each kind of process and obtain a differentiated result. As has been obtained from the empirical study, HR practices and knowledge exploration do not interact significantly and thus there is not a moderating effect with regards to innovation. Future studies could look in greater depth at the relationship between specific HR practices, KM processes and differentiated innovation outcomes such as process vs product, technological vs administrative, or radical vs. incremental. Third, this study uses self-report data which may have the possibility of common method variance. Although the Harman test does not show it to be a significant problem, the issue may still exist. Future research could benefit from using objective measures of innovation that can be independently verified. Fourth, this study applied the *t*-statistic test to verify that non-response bias was not a significant issue. However, the low return rate of the survey is still a potential limitation. Moreover, instead of innovative industries, future research might focus on more diverse industries and a larger sample of firms, in order to validate the results of the study. The research has also focused on Spanish companies and potential cultural limitations may exist, so future research could apply the empirical work in different cultural contexts to generalize or modify the concepts.

Organizational culture, leadership and HR practices oriented to knowledge become essential to perform and enhance exploration and exploitation results. Organizational factors and KM practices are mutually reinforced thus improving innovation performance. This empirical evidence has important implications for managers and it advances the research about the moderating effects of organizational culture, HR practices design, and leadership for the implementation of KM strategies oriented to innovation.

Notes

1. Since the authors' purpose is to address the human factors that drive successful KM, the analysis of the technical area has not been considered in this study. Furthermore, as extensive literature on the role of technology in KM already exists (DeTienne *et al.*, 2004), this component is not specifically discussed in this paper.
2. Initiating structure refers to the extent to which the leader is likely to define and structure his or her role and those of subordinates in the search for goal attainment. It includes behavior that attempts to organize work, work relationships and goals (Robbins, 1997, p. 322). On the other hand, consideration refers to the extent to which a person has job relationships characterized by mutual trust and respect for subordinates' ideas and feelings (Robbins, 1997, p. 322).
3. While transactional leadership theories focus on leader-follower exchanges in the form of benefits, rewards, incentives and self-interest, the transformational leadership approach emphasizes the motivation and inspiration of followers to give their best; i.e. in the transformational perspective the organization endeavor to place performance before expectations through members' value-based self-sacrifice and a common sense of higher purpose that applies to both leaders and followers (von Krogh *et al.*, 2011, p. 9).
4. The DL section of the Spanish CNAE-93 includes four two-digit codified divisions (industries): 30 (manufacturing of office machines and computer equipment), 31 (manufacturing of electric materials and machinery), 32 (manufacturing of electronic material) and 33 (manufacturing of medical-surgical, optical and watch-making materials).

5. Databases used to gather the information referred to companies were: Fomento de la Producción – 30.000 (30.000 – Manufacturing Promotion) and SABI (Analysis System of Iberian Accounts).
6. The multi-item indicators built by He and Won (2004) are a notable exception. Nevertheless, for the authors' purposes these measures did not reflect knowledge exploration and exploitation practices since they are referred to exploitative and explorative innovation. In the authors' opinion, this is mostly related to radical or incremental innovations pursued by the firm (introduce a new generation of products, extend product range, open up new markets, enter new technology fields, improve existing product quality, improve production flexibility, reduce production cost, improve yield or reduce material consumption) rather than KM practices.
7. Alavi *et al.* (2005) point out that cultural values are easier to establish than other concepts such as artifacts or organizational assumptions, which are difficult to conceptualize and delineate.
8. The SPSS 12.0 software was used in this study to carry out all the statistical analyses.

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Further reading

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Appendix

Knowledge exploration practices. Over the last three years in the company (from 1 – totally disagree to 7 – totally agree):

- There has been a strong commitment to depend on internal activities of R&D to develop or improve technologies (products, processes) (Exploration1).
- There has been a strong investment on R&D activities to develop or improve internally technologies (products, processes) (Exploration2).
- There has been a strong commitment to using proprietary technology to develop or improve products/processes (Exploration3).
- There has been a strong commitment to maintain a highly qualified R&D unit to develop or improve technologies (products, processes) (Exploration4).

Knowledge exploitation practices. Over the last three years in the company (from 1 – totally disagree to 7 – totally agree):

- It has been promoted databases that allow gathered knowledge and experiences to be used later are available in the company (Exploitation1).
- Phone or e-mail directories (referring to departments and sections) have been developed to find experts in specific areas (Exploitation2).
- It is possible to access knowledge repositories, databases and documents through some kind of internal computer network (such as an intranet or similar, for instance) (Exploitation3).
- There are periodical meetings in which employees are informed about new changes that have been implemented in the firm (Exploitation4).
- There are formal mechanisms that guarantee best practices are shared in the firm (for instance, among departments or business areas) (Exploitation5).
- There are projects with interdisciplinary teams in order to share knowledge (Exploitation6).

- There are employees that compile suggestions from other employees, customers and suppliers, and who then make elaborated structured reports for distribution within the firm (Exploitation7).
- There are communities of practices or groups of learning to share knowledge and experiences (Exploitation8).
- There are interdisciplinary teams with autonomy to apply and integrate knowledge (Exploitation9).
- Suggestions from employees, customers or suppliers are frequently incorporated into products, processes or services (Exploitation10).
- Knowledge that has been created is structured in independent modules, which allows its integration or separation in order to create different applications and new uses of this knowledge (Exploitation11).

Knowledge-centered culture. Over the last three years in the company (from 1 – totally disagree to 7 – totally agree):

- There has been a common language to support knowledge exchange and sharing between employees and departments (Culture1).
- An effort is made to encourage employees to experiment and implement new ideas in their working day (Culture2).
- An effort is made to inform employees that mistakes are a learning consequence and are tolerated up to a certain limit (Culture3).
- Culture is based on confidence and openness (Culture4).
- The employees are encouraged to share knowledge at an informal level (Culture5).
- The employees demonstrate responsible behavior and a high learning disposition (Culture6).
- All organizational members perceive the same purpose and feel bound to it (Culture7).

Knowledge-oriented leadership. Over the last three years in the company (from 1 – totally disagree to 7 – totally agree):

- Leadership is creating an environment for a responsible behavior of employees and work in teams (Leadership1).
- Managers are accustomed to assuming the role of knowledge leaders which it is mainly characterized by openness, tolerance to mistakes and mediation for the achievement of the firm's objectives (Leadership2).
- Managers promote learning from the experience, tolerating mistakes up to a certain point (Leadership3).
- Managers behave as advisers, and controls are just an assessment of the accomplishment of objectives (Leadership4).
- Managers promote the acquisition of external knowledge (Leadership5).
- Managers reward employees who share and apply their knowledge (Leadership6).

Knowledge-centered HR practices. Over the last three years in the company (from 1 – totally disagree to 7 – totally agree):

- Training programs have been developed as an essential instrument for the objectives attainment (HRpractice1).
- Incentive systems (monetary and non-monetary) have been developed to reward team-work, instead of individual incentives systems (HRpractice2).
- Programs of internal rotation have been developed, which make the employees pass through different departments or develop diverse functions (HRpractice3).
- Participative mechanisms for the resolution of problems have been carried out (HRpractice4).
- Methods have been put into practice to asses and control KM processes (creation, storage, transfer, application . . .) (HRpractice5).

- Teamwork has been promoted as a regular practice (HRpractice6).

Innovation results. Assessment of the level of technological results obtained in the last year for this company (from 1 – very low to 7 – very high):

- Development of new production methods and procedures (Innovation1).
- Development of improvements for existing methods and procedures (Innovation2).
- Introduction of more new (or improved) methods and procedures than its major competitors (Innovation3).
- Introduction of more new (or improved) methods and procedures than three years ago (Innovation4).
- Development of new products (Innovation5).
- Modification and/or improvement of existing products (Innovation6).
- Introduction of more new (or improved) products than its major competitors (Innovation7).
- Introduction of more new (or improved) products than three years ago (Innovation8).

R&D spending. Assessment of the spending on R&D over the last three years for this company: (from 1 – very low to 7 – very high):

- Level of spending on R&D over the last three years (R&D1).
- Level of spending on R&D as compared to the main competitor (R&D2).
- Level of spending on R&D as compared to the former three year period (R&D3).
- Level of spending on R&D as compared to the average spending in the industry (R&D4).

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