Título artículo / Títol article:	External knowledge acquisition and innovation output: an analysis of the moderating effect of internal knowledge transfer
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Revista:	Knowledge Management Research & Practice
Versión / Versió:	**Post-print**
Cita bibliográfica / Cita bibliogràfica (ISO 690):	SEGARRA-CIPRÉS, Mercedes; ROCA-PUIG, Vicente; BOU-LLUSAR, Juan Carlos. External knowledge acquisition and innovation output: an analysis of the moderating effect of internal knowledge transfer. Knowledge Management Research & Practice, 2014, vol. 12, no 2, p. 203-214.
url Repositori UJI:	http://hdl.handle.net/10234/123743

External knowledge acquisition and innovation output: an analysis of the moderating effect of internal knowledge transfer

Abstract

Numerous studies highlight the advantages of accessing knowledge from outside the firm as a means of enhancing the firm's innovation efforts. However, access to external knowledge is not without organisational problems, including rejection of external knowledge by firm members or difficulties in applying such knowledge to the firm's operations. Based on the knowledge management literature, this paper analyses the conditions within the firm that favour external knowledge acquisition, and focuses on internal transfer as a key variable for the successful integration of external knowledge in the innovation process. Our results demonstrate that internal knowledge transfer intensifies the influence of external knowledge acquisition on innovation output. Specifically, achieving an environment within the firm that favours knowledge integration into the innovation process depends to a large extent on the willingness of knowledge users to share and assimilate knowledge, and on the existence of formal mechanisms such as coordination and communication.

Keywords: knowledge acquisition, knowledge transfer, knowledge sharing, innovation.

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Introduction

Market dynamism, increased worker mobility and rapidly changing information technologies have brought about a situation in which the knowledge a firm requires to innovate may be found in a wide range of countries, organisations and people. Some authors (e.g. Chesbrough, 2006; Leiponen and Helfat, 2010) suggest that today, innovation advantage does not lie so much in the organisation's internal resources, but rather in its capacity to identify valuable external knowledge and incorporate it into its own innovation process. Because of this context of competitiveness, firms' activities to acquire and transfer knowledge are now fundamental to the management of technological knowledge.

Concerning the way knowledge acquisition contributes to innovation development, various authors (e.g. Ahuja and Lampert, 2001; Ahuja and Katila, 2004; Katila and Ahuja, 2002; Leiponen and Helfat, 2010) have shown that innovation success is more fully explained when firms search widely for knowledge in a variety of technological domains and geographical locations. However, the scope of the search for knowledge has certain limits and may even give rise to organisational problems. For instance, external knowledge may not be accepted by the firm's employees (Laursen and Salter, 2006), a syndrome known as *Not Invented Here* (NIH) in which some members of the firm reject knowledge from external sources (Lichtenthaler and Ernst, 2006). A second drawback associated with the overuse of external sources are the high marginal costs deriving from the complexity of managing both a wide variety of knowledge and the relationships necessary to maintain access to these sources (Leiponen and Helfat, 2010). Furthermore, access to external knowledge sources does not automatically translate in innovation output; firms must also develop capacities that enable them to apply external knowledge in order to generate innovations.

Organisations should therefore develop capacities that enable external knowledge to be assimilated, shared and incorporated into their innovation processes. In this vein, innovation research demonstrates that knowledge transfer capacity favours the integration of knowledge and its incorporation in the development of new products and services (Darr *et al.*, 1995; Hargadon and Sutton, 1997; Miller *et al.*, 2007; Van Wijk *et al.*, 2008). Some of the reasons given to support this relationship are that knowledge transfer broadens and enhances the knowledge base available for the organisation's members to work with (Hansen *et al.*, 2005). Members of the organisation who receive more accurate information are likely to become more sensitive to clients' needs, respond more rapidly to their demands and meet their requirements more satisfactorily (Wu, 2008). In addition, intra-organisational knowledge transfer can foster the development of new products because it increases the capacity to form new relationships and associations (Jansen *et al.*, 2005) and eases the integration and combination of specialised knowledge (Smith *et al.*, 2005). Finally, *intra*-organisational knowledge transfer contributes to the firm's outcomes to a greater extent than *inter*-firm knowledge transfer, because the units within the firm are more likely to focus on knowledge that is relevant at a given moment and at a specific place, with the effect that the knowledge will be exploited more easily (Van Wijk *et al.*, 2008).

Drawing on these arguments, the main aim of this research is to identify the internal conditions in the firm that favour the integration of external knowledge, with a particular focus on internal transfer as a key variable to achieve successful integration of external knowledge. Specifically, we analyse the extent to which the capacity of knowledge users to assimilate and share knowledge, together with the internal transfer context, favour the use of external knowledge as part of the innovation process.

This objective is pursued as follows: the next section presents the theoretical bases for the contribution of knowledge management activities to innovation development. Our research model is grounded on this review, and consists of analysing the direct effect of external knowledge acquisition on innovation development and the moderating effect of internal knowledge transfer on the relationship between knowledge acquisition and innovation output. We then describe the methodological aspects of the research and present the results. The main conclusions and implications of the study are discussed in the final section.

Theoretical background and hypotheses

The knowledge management literature highlights the importance of different knowledge management activities such as acquisition, storing, transfer and application or exploitation of knowledge in achieving the organisation's objectives and in obtaining competitive advantages (Shin *et al.*, 2001; Staples *et al.*, 2001; Chakravarthy *et al.*, 2003; Argote *et al.*, 2003). One stream of research within the Knowledge Based View (KBV) explores how these activities contribute to innovation development (e.g. Birkinshaw and Fey, 2005; Caloghirou *et al.*, 2004; George *et al*, 2001; Leiponen and Helfat, 2010; Smith *et al.* 2005). These studies show that by acquiring external knowledge, the firm accesses externally generated knowledge that can be essential to the development of its innovative activity. Moreover, storing and retention of knowledge reflects organisations' learning, and enables stored knowledge to be used whenever it is needed. Both personnel and information technologies are important in this process and when they operate in conjunction, knowledge storage and retrieval processes are both enhanced (McGrath and Argote, 2002). Internal knowledge transfer facilitates knowledge mobility within the organisation, and encourages coordination among members of the firm and the integration of external knowledge into the organisation (Schulz and Jobe, 2001). The quality and quantity of interactions among employees, together with their willingness and ability to use knowledge, will encourage a situation in which knowledge exchange occurs among the organisation's members (Lagerstrom and Andersson, 2003; Liao, 2008). Finally, the application or exploitation of knowledge implies that knowledge is used in carrying out all the firm's activities (Zahra and George, 2002).

Knowledge acquisition, knowledge transfer and innovation

Since the main objective of this analysis is to learn which of the firm's internal conditions encourage the integration of external technological knowledge in the innovation process, our interest focuses on two knowledge management activities: knowledge acquisition and internal knowledge transfer. By acquiring knowledge, firms can identify and access relevant knowledge from beyond their boundaries (Eisenhardt and Santos, 2002). The increasing use of external sources has been attributed to a rise in the complexity and interdisciplinarity of the R&D process, to higher uncertainty associated with R&D outputs, and to the greater increase in the costs of R&D projects together with shorter technology life cycles (Hagedoorn, 2002; Howells *et al.*, 2003). In general, most research on high technology sectors concludes that they tend to be more open in the area of innovation (Hagedoorn, 1993; Wang, 1994; Bayona *et al*., 2001; Tether, 2002). This is because few firms in these sectors can achieve the required levels of complexity and knowledge on their own; even the most diversified firms need to cooperate in order to obtain economies of scale and scope and respond rapidly to the market. More recently, some studies find that the search for knowledge is also an increasingly widespread activity in low technology-intense sectors (Chesbrough and Crowther, 2006; Grimpe and Sofka, 2009; Tsai and Wang, 2009; Santamaría, Nieto, and Barge-Gil, 2010; Segarra *et al.*, 2012). The reason for this trend towards the search for external knowledge as a source of innovation lies in the fact that knowledge is now more widely dispersed, and in the need – even in organisations with highly competent R&D departments – to identify and connect with and external sources of knowledge (Chesbrough, 2006). These arguments lead us to our first hypothesis:

> *Hypothesis 1: External knowledge acquisition has a positive effect on innovation output.*

Knowledge acquisition, however, does not guarantee that the knowledge will be exploited internally, or that it will be accepted within the organisation. In this study, we therefore propose that the capacity to transfer knowledge internally is essential for the integration of external knowledge. Thus, internal knowledge transfer enables inter-organisational knowledge flows to become more efficient, so the organisation can exploit knowledge in the same way as it exploits any other resource (Szulanski, 1996). Pioneering studies on knowledge transfer (Szulanski, 1996; Minbaeva *et al.*, 2003; Argote *et al.*, 2003) state that knowledge transfer can be understood as a process in which different elements (knowledge users and the transfer context) play a part. This understanding of transfer allows us to make a diagnosis of the effect that each element has on the result of the firm's processes, which can be used to design organisational mechanisms that favour organisational outcomes. In a context of knowledge creation and transfer, R&D personnel are the main users of knowledge, since they are the most knowledge-intensive and professional group in an organisation (Liao, 2008). R&D teamwork can be regarded as a cooperative human problem-solving process. Their knowledge and expertise is vital to new product development and their capability is the major determinant of product development strategy (Henard and McFadyen, 2006).

Knowledge users' capacity to assimilate and share knowledge

According to Nonaka and Takeuchi (1995), knowledge creation and innovation must be understood as a process by which the knowledge individuals possess is extended and internalised as part of the organisational knowledge. If an organisation's internal knowledge is not shared with other people and groups in the organisation, it will remain at the individual level and will have little or no impact on the firm's innovation output or capacity (Nonaka and Takeuchi, 1995; Ipe, 2003; Subramaniam and Youdt, 2005). The knowledge users' capacity to assimilate new knowledge and their willingness to share their individual knowledge is therefore crucial in the creation of new knowledge. In the context of internal knowledge transfer, we understand assimilation capacity to mean the set of routines and processes that allow knowledge users to analyse, interpret and understand new knowledge (Zahra and George, 2002). This capacity therefore includes the knowledge users' ability to learn new knowledge, and must be accompanied by a willingness on the part of organisational members to share their knowledge so that new knowledge can be transferred.

Recent studies also highlight the importance to innovation of sharing knowledge (e.g. Brachos *et al.*, 2007; Swan *et al.*, 2007; Seidler-de Alwis and Hartmann, 2008; Camelo *et al*., 2011). For example, Seidler-de Alwis and Hartmann (2008) find that organisations in which knowledge sharing processes are promoted enjoy greater innovation success. Brachos *et al.,* (2007) also reports that innovation improves when the factors needed to motivate individuals to share and transfer knowledge are present. Hence, assimilating and sharing knowledge are processes that enable individual knowledge and group knowledge to be transferred to the organisational level where it can be applied to develop new products, services and processes (Van den Hooff and Ridder, 2004). This process therefore enables individuals to contribute to the organisation's knowledge set as a whole, and not only leads to the improved use of existing knowledge, but also creates new knowledge (Huang *et al.*, 2008).

In the following hypotheses we posit the positive moderating effect of firm R&D members' capacity to assimilate and share knowledge in the relationship between acquisition of knowledge and innovation output:

> *Hypothesis 2: The capacity of the firm's R&D personnel to assimilate knowledge has a positive effect on the relationship between knowledge acquisition and innovation output.*
>
> *Hypothesis 3: The capacity of the firm's R&D personnel to share knowledge has a positive effect on the relationship between knowledge acquisition and innovation output.*

Internal knowledge transfer context

When firms possess the appropriate resources and capacities, an internal environment favourable to innovation facilitates the adoption and introduction of new products and processes and, in the end, innovation outputs (Urgal *et al.*, 2011). According to Prajogo and Ahmed (2006), the role of managers in innovation management is to create organisational contexts favourable to innovation. Hence, managerial efforts should focus on creating and maintaining an environment within the organisation that supports innovation, such that employees will be both willing and able to innovate. Moreover, people tend to be naturally resistant to sharing what they know and, even if they are willing to do so, knowledge – particularly tacit knowledge – does not flow easily. Sharing knowledge is therefore a complex task requiring considerable time and effort on the part of the individual (Ardichvili, 2008). Various related studies emphasise the role of communication and coordination among the organisation's members as essential elements in shaping a favourable context for internal knowledge transfer (Dougherty, 1992; Gresov and Stephens, 1993; Ghoshal *et al.*, 1994; Hansen, 1999; Nonaka *et al.*, 2000; Tsai, 2002). According to Dougherty (1992), coordination and communication among participants in knowledge integration determines the successful development of innovations. Nonaka *et al.* (2000) also highlight the importance of context in creating knowledge in terms of who participates in the creative process and how this takes place. Several authors have stressed the importance of formal and informal communication as critical processes for the effective transfer of knowledge. For example, Ipe (2003) reports that although formal systems of communication facilitate the knowledge sharing process, research demonstrates that much of the transferred knowledge is shared in informal contexts through relational learning channels (Pan and Scarbrough, 1999; Ipe, 2003). These channels foster direct communication among members, encouraging trust and the transmission of tacit knowledge (Nishimoto and Matsuda, 2007). Frequent interactions over time establish rich communication channels and common understanding that enhance the ability of the organisation's members to evaluate, understand and accurately use the transferred knowledge (Tortoriello and Krackhardt, 2010). In summary, the closer the relationship among knowledge users, the higher the likelihood that the knowledge one user needs will match the knowledge offered by another user. This in turn enhances their abilities to use the new knowledge for their own purposes and transform it into a specific output. These arguments lead us to propose the following hypotheses:

Hypothesis 4: Coordination among the firm's R&D personnel has a positive effect on the relationship between knowledge acquisition and innovation output.

Hypothesis 5: Fluent communication among the firm's R&D personnel has a positive effect on the relationship between knowledge acquisition and innovation output.

Our research model, grounded on this frame of analysis, supposes that external knowledge acquisition has a positive effect on innovation output, and this relationship will be favoured in as far as members of the firm are willing and able to assimilate and share external knowledge. It will also depend on a transfer context that promotes communication and coordination among members in order to integrate knowledge from external sources into the firm's innovation process. Our research model is set out below (figure 1):

INSERT FIGURE 1 ABOUT HERE

METHODS

Sample

Two criteria were adopted for selecting the companies of the target population: (1) they should be innovative firms; and (2) they should possess an R&D department or equivalent. Regarding the first selection criterion, the literature shows that knowledge transfer processes are especially important for those companies that need to innovate in order to maintain and enhance their competitive advantage (Thompson and Heron, 2005, 2006; Huang *et al.*, 2008; Camelo *et al.*, 2011). The study was carried out on a sample of innovative technology-based firms (ITBFs). These are knowledge intensive firms; in other words technological knowledge is one of the essential inputs of their activity. The term ITBF covers all organisations producing goods and services, committed to the design, development and production of new products and/or innovative manufacturing processes through the systematic application of technical and scientific knowledge (Simón, 2003). These firms operate in areas such as precision mechanics, electronics, chemicals, IT, communications, biotechnology, etc. The sample was selected from the Spanish CDTI (Centre for the Development of Industrial Technology) national database. The sample represents firms from a range of sectors; however those belonging to four sectors predominate: the chemical industry (20%), manufacture of machinery and equipment (15%), the food and drink industry (11%) and the medical, precision and optical instruments, watches and clocks sector (9%).

The second selection criterion establishes that the companies to be included in the population should have an R&D department. The reason for this decision is that the R&D department is the organisational area that assumes the highest responsibility for knowledge-creation processes, and, therefore, it is the area in which knowledge-transfer processes acquire the most importance (Thompson and Heron, 2005, 2006; Camelo *et al*., 2011). All the sample firms share a commitment to R&D, in that all have an R&D department and develop new products, and 49% of the firms had registered a patent in the three years prior to the study.

A total of 916 questionnaires were sent out to R&D managers, and 188 valid responses were obtained. The questionnaire was sent to the R&D manager in each firm, as the person with the most comprehensive and thorough information on the workings of the department (Snow and Hrebiniak, 1980). The selection of the R&D manager as the primary informant meets two accepted criteria for identifying appropriate key respondents (Pla and Alegre, 2007): 1) s/he has specialised knowledge on the subject under study; 2) s/he has an appropriate level of involvement with the research topic (Campbell, 1955).

Measurement of Independent, Dependent and Moderating Variables

Dependent variable. Innovation output was measured on a seven-point Likert scale constructed by selecting indicators from the innovation literature in order to reflect two aspects of innovation output, namely: a) the time, cost and satisfaction involved in undertaking R&D projects (Wheelwright and Clark, 1992; Hoopes and Postrel, 1999; McEvily and Chakravarthy, 2002; Szulanski, 2003); and b) the impact the innovation has on the firm's products (Laursen and Salter, 2006; OCDE, 2005). The scale items are presented in the appendix (table 1).

Independent variables. The scale used to measure external knowledge acquisition contains four items generated from the knowledge acquisition literature (Bierly and Hämäläinen, 1995; Lyles and Salk, 1996; George *et al*., 2001; Stock *et al*., 2001; Almeida *et al*., 2003; Caloghirou *et al*., 2004; Chen, 2004).

Moderating variables. We referred to studies by Gresov and Stephens (1993), Ghoshal *et al.* (1994), Szulanski (1996), Hansen (1999), Tsai (2002) and Cavusgil *et al.* (2003) to generate the indicators for the communication and coordination scales. The capacity of R&D personnel to assimilate and share knowledge was measured on a scale based on studies by Leonard-Barton and Deschamps (1998), Szulanski (1996), Kostova (1999), Gupta and Govindarajan (2000), Osterloh and Frey (2000), Steensma and Lyles (2000), Wang *et al.* (2001), Minbaeva *et al.* (2003), with the modifications necessary for our study. The items included in each of the seven-point Likert scales are presented in the appendix (table 1).

In line with recommendations by Churchill (1979) and DeVellis (1991), we developed the measurement scales for the concepts of the study. According to these authors, a literature review should provide the base on which to construct a scale. This theoretical review enabled us to define the theoretical concepts, specify the aspects or dimensions of these concepts and generate a series of observable indicators. We then took expert opinions into account to refine the scales, which in many cases involved eliminating redundant or unnecessary items and improving the wording of the questions. An electronic questionnaire was then prepared in order to obtain the data by email. Finally we analysed the scales' properties, on the basis of the three aspects of dimensionality, reliability and validity.

Statistical Procedure and results

We first consider the issue of common method variance, since only one person had evaluated all the variables in the study. If common method variance exists, Harman's single factor test (Podsakoff *et al.*, 2003; Podsakoff and Organ, 1986) will reveal a single factor from a factor analysis of all the survey items. This test consists of a confirmatory factor analysis (CFA) in which all the items from all the research constructs are considered in order to determine whether most of the variance can be explained by a single general factor (Podsakoff *et al.*, 2003). The results of this CFA (Satorra Bentler χ^2 = 835.90; *df* = 230; *p* = .00; Bentler-Bonnet Non-Normed Fit Index = 0.469; Comparative Fit Index (CFI) = 0.517; Root Mean-Square Error of Approximation (RMSEA) = 0.10) confirmed the absence of common method variance in our study, as the indexes were all above the accepted values.

Table 2 reports the means, the standard deviations and the correlations for all variables in the analysis. The variables include 23 indicators corresponding to components of knowledge acquisition (X1-X4), knowledge sharing capacity (X5-X8), knowledge assimilation capacity (X9-X12), coordination (X13-X15), communication (X16-X18) and innovation output (Y1-Y5).

INSERT TABLE 2 ABOUT HERE

Structural equation models provide an appropriate data analysis technique for the type of variables used and the relationships posited in our hypotheses since they allow us to: 1) verify whether the scales used are appropriate to measure the theoretical concepts and, 2) analyse the relationships between the theoretical concepts. We used the EQS 6.1 statistical program (Bentler,

1995) to estimate and evaluate the measurement and structural models. Thus, we first develop the measurement model based on confirmatory factor analysis, and from this, we build the structural model.

We performed a CFA for each one of the research constructs in order to test their dimensionality. The results confirmed that all the CFA fit indexes for the measurement scales fell within the accepted limits. Regarding the reliability and validity of the scales, the compound reliability and the reliability of each indicator enabled us to confirm that all the standardized factor loadings are significant and higher than 0.5. In addition to the content validity supported by the literature review, we verified that the constructs met the convergent validity requirements (Bentler-Bonett coefficient ≥ 0.9).

The hypotheses were tested using structural models, in other words, by estimating the corresponding covariance structure models (figure 2). By applying these models, it is relatively simple to test H1. This consists of checking the significance of the parameter that estimates the relationship between the variables that define the hypothesis. The first hypothesis proposed the direct effect of knowledge acquisition (ACQ) on innovation output (IO). The equation for this hypothesis is as follows (1):

$$IO = \alpha + \gamma_1 ACQ + \zeta \quad (1)$$

However, testing the remaining hypotheses is a more complex process, since it involves studying the moderating effect. Specifically, we adopted the latent variable scores approach (Jöreskog *et al.*, 2003; Jöreskog, 2000) to analyse the moderating effect of the firm's capacity to share and assimilate knowledge and coordination and communication among its R&D personnel on the relationship between external knowledge acquisition and innovation output. The interaction latent variable is obtained by multiplying the scores of the independent latent variables. To apply this method we first estimate the structural model underlying each hypothesis (hypotheses 2, 3, 4 and 5), excluding the interaction term, in order to evaluate the overall fit of the model. We then calculate the scores of the latent variables that appear in the model, that is, knowledge acquisition (FSACQ), knowledge assimilation (FSASSI), knowledge sharing (FSSHARE), coordination (FSCOOR) and communication (FSCOM); we calculate three factor scores for each hypothesis. Next, we calculate the interaction term of the factor scores of the independent variables. Finally we estimate the regression equations that compute the coefficients of the direct effects and the interaction effect. These multiple regression equations include the factor score of the dependent variable, the factor scores of the independent variables and the results of the factor scores of the independent variables (figure 2). The equations for hypotheses 2, 3, 4 and 5 are given below.

$$FSOI = \alpha + \gamma_1 \, FSACQ + \gamma_2 \, FSASSI + \gamma_3 \, FSACQASSI + \zeta \quad (2)$$

$$FSOI = \alpha + \gamma_1 \, FSACQ + \gamma_2 \, FSSHARE + \gamma_3 \, FSACQSHARE + \zeta \quad (3)$$

$$FSOI = \alpha + \gamma_1 \, FSACQ + \gamma_2 \, FSCOOR + \gamma_3 \, FSACQCOOR + \zeta \quad (4)$$

$$FSOI = \alpha + \gamma_1 \, FSACQ + \gamma_2 \, FSCOM + \gamma_3 \, FSACQCOM + \zeta \quad (5)$$

INSERT FIGURE 2 ABOUT HERE

Table 3 reports the results for the fit of the structural models of the five proposed hypotheses. All five models present an adequate fit, as the fit indexes fall within the commonly accepted limits. Table 4 reports the estimated parameters in the structural models for the five hypotheses. The results for the first model confirm the positive and significant effect of knowledge acquisition on innovation output. Regarding the moderating effects posited in the other four hypotheses, the interaction effect (γ_3) was positive and significant in all the models estimated. The capacity of R&D personnel to share knowledge with their colleagues (hypothesis 2) and to assimilate external knowledge (hypothesis 3) were both shown to favour the effect of knowledge acquisition on innovation output. This result coincides with studies (e.g. Smith *et al.*, 2005; Camelo *et al.*, 2011) highlighting the role of R&D personnel in integrating external knowledge and in innovation in the firm. Finally, when hypotheses 4 and 5 were tested, the moderating effect of R&D personnel's capacity to communicate and coordinate was also corroborated. Hence, the formal mechanisms that foster interaction among knowledge users also facilitate the integration and creation of new knowledge, by enabling individual knowledge to be turned into organisational knowledge, thereby increasing the value of this asset to the organisation.

INSERT TABLE 3 ABOUT HERE

INSERT TABLE 4 ABOUT HERE

CONCLUSIONS AND DISCUSSION

As previous studies have shown (Laursen and Salter, 2006; Lichtenthaler and Ernst, 2006; Leiponen and Helfat, 2010), access to external knowledge is not without organisational problems including rejection of external knowledge within the firm or difficulties in applying external knowledge to the firm's operations. In this study, therefore, we have attempted to shed some light on the possible mechanisms that enable firms to overcome the problems they face in using external knowledge as an input in the innovation process. Based on the knowledge management literature, we suggest that expanding the capacity for internal knowledge transfer can favour external knowledge integration. Our results demonstrate that internal knowledge transfer intensifies the influence of external knowledge acquisition on innovation output. In addition, our study finds that in order for acquired knowledge to become integrated into the organisation's knowledge base, the individuals involved in the innovation process must be willing to share knowledge and able to assimilate external knowledge. Employees in the R&D department have an important role in this process, since they can enhance the firm's competitive advantage through the effective generation, use, transfer and integration of knowledge (Liao, 2008; Ortín and Santamaría, 2009; Camelo *et al.*, 2011). We also find that a context for transfer that promotes coordination and communication among members of the firm encourages the integration of external knowledge and the acquisition of new knowledge. An internal context in which interaction among employees is encouraged facilitates problem solving and experimentation (Kivimäki *et al.*, 2000). Therefore, a greater number of direct channels among members of the organisation not only provides potential access to individual and organisational knowledge resources, but also increases the ease and scope of knowledge transfer (Koka and Prescott, 2002; McFadyen and Cannella, 2004). These findings are in line with results of other studies that show how the ability of members of the organisation to exchange and combine knowledge, together with a context of favourable relationships, contribute to encourage innovation development (Tornatzky and Fleischer, 1990; Dougherty, 1992; Brown and Eisenhardt, 1995; Smith *et al.*, 2005). More specifically, Davenport and Prusak (1998) point out certain initiatives that favour knowledge transfer capacity such as fostering employee flexibility and learning as a way of overcoming the lack of assimilation capacity among knowledge users. With regard to willingness to share knowledge, these authors recommend building relationships of trust between parties, removing the negative effect of hierarchy, trying to be more tolerant of others' mistakes and rewarding collaboration. Interventions to encourage a healthy environment for transfer include the need to establish favourable times and locations for knowledge exchange.

In sum, from a knowledge management perspective, achieving an environment within the firm that favours innovation depends to a large extent on the willingness of knowledge users to share and assimilate knowledge, and on the existence of formal mechanisms such as coordination and communication, conditions that enable the organisation to become more involved in the innovation process. These aspects define the context in which technological innovation activities are developed and, specifically, the organisation's attitude towards innovation, and therefore condition the process by which resources are transformed into innovation output. Future research might explore in greater depth the organisational mechanisms that can encourage internal knowledge transfer. Work in this line includes Minbaeva *et al.* (2003), Minbaeva (2005) Zárraga and Bonache (2005) and Camelo *et al.* (2010), who propose that certain human resource and organisational practices favour the transfer and creation of knowledge. For example, Zárraga and Bonache (2005) propose a series of mechanisms such as appointing a work team leader or coordinator, creating a system of incentives linked to knowledge transfer, teamwork training and firm social events. These mechanisms help to encourage a shared organisational context that facilitates the transfer and creation of knowledge within work teams. For their part, Camelo *et al.* (2010) highlight the importance of motivational aspects, such as affective commitment, and of contextual aspects like informal communication and the use of structured work teams, in fostering knowledge sharing processes.

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Appendix

INSERT TABLE 1 ABOUT HERE

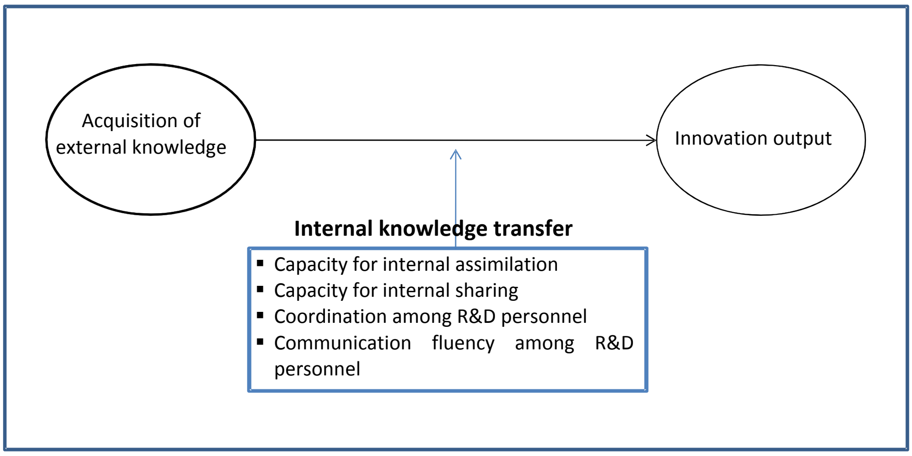

Figure 1. Research model.

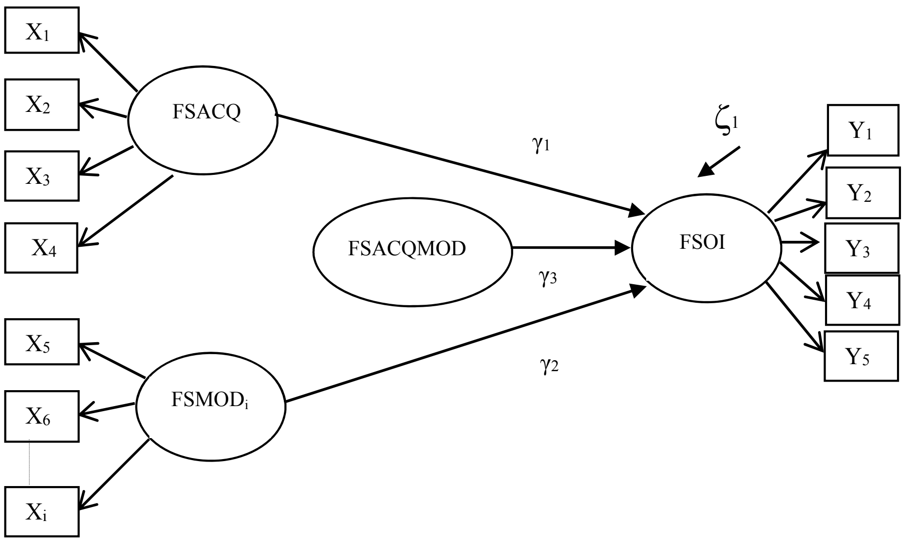

Figure 2. Latent variable score interaction model

Note: MOD_i = Moderator variables (ASSI, SHARE, COM, COOR)

Table 1 Scales used to measure the research model constructs.

Innovation output (IO)

Y1. Development of technologically new products.

Y2. R&D department success in developing R&D projects

Y3. Little difference between the time foreseen to develop the project and the actual time spent

Y4. Degree of satisfaction with the development of R&D projects

Y5. Developments in manufacturing technologically new products or improvements in the firm's total production.

External knowledge acquisition (ACQ)

X1. Search for information in the environment

X2. Monitoring of customers' needs

X3. Contacts with external institutions or specialised sources

X4. Availability within the firm of people, teams or services specialised in environmental scanning.

Knowledge sharing capacity (SHARE)

X5. The R&D department is open to change.

X6. The members of the R&D department are willing to share knowledge with their colleagues.

X7. The members of the R&D department share knowledge because it enables them to solve problems and do their work better.

X8. There is a sufficient level of trust among members of the R&D department for knowledge to be shared.

Knowledge of assimilation capacity (ASSI)

X9. The R&D personnel's professional experience enables them to assimilate new knowledge easily.

X10. The R&D personnel's professional experience enables them to take on intense technological changes.

X11. The R&D personnel's professional experience enables them to assimilate new knowledge more easily than other members of the firm.

X12. The R&D personnel's professional experience encourages exchange of knowledge among members of the department.

Coordination (COOR)

X13. To what extent does the R&D department use meetings, work teams or committees to undertake its work?

X14. To what extent do workers in the R&D department interrelate and work closely together in carrying out their work?

X15. Note the degree of informal interaction among members of the R&D department (taking coffee or lunch breaks together, etc.).

Communication (COM)

X16. Note the frequency with which meetings are held in the R&D department

X17 Note the frequency of interaction between members of the R&D department

X18. Assess the frequency with which members of the R&D department use different means of communication to communicate with each other.

Table 2. Descriptive statistics and correlations

	Mean	s.d.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
X1. External knowledge acquisition	5.32	1.293	1																						
X2. External knowledge acquisition	6.15	0.877	0.316**	1																					
X3. External knowledge acquisition	4.88	1.372	0.432**	0.144*	1																				
X4. External knowledge acquisition	4.42	1.480	0.438**	0.228**	0.468**	1																			
X5. Knowledge sharing capacity	6.10	0.784	0.116	0.133	0.141	0.124	1																		
X6. Knowledge sharing capacity	6.23	0.785	0.186*	0.090	0.175*	0.133	0.440**	1																	
X7. Knowledge sharing capacity	1.99	1.308	-0.118	-0.050	-0.072	-0.017	-0.270**	-0.440**	1																
X8. Knowledge sharing capacity	6.13	0.833	0.104	0.039	0.075	0.006	0.372**	0.542**	-0.367**	1															
X9. Knowledge of assimilation capacity	5.94	0.838	0.211**	0.137	0.249**	0.177*	0.368**	0.234**	-0.181*	0.242**	1														
X10. Knowledge of assimilation capacity	5.66	0.982	0.254**	0.202**	0.271**	0.202**	0.434**	0.303**	-0.190**	0.272**	0.760**	1													
X11. Knowledge of assimilation capacity	5.81	0.966	0.193**	0.165*	0.269**	0.141	0.335**	0.346**	-0.205**	0.357**	0.639**	0.700**	1												
X12. Knowledge of assimilation capacity	5.73	1.067	0.155*	0.186*	0.215**	0.193**	0.397**	0.322**	-0.178*	0.269**	0.627**	0.623**	0.710**	1											
X13. Coordination	5.44	1.288	0.215**	0.160*	0.236**	0.268**	0.115	0.276**	-0.184*	0.140	0.105	0.122	0.212**	0.159*	1										
X14. Coordination	5.79	0.924	0.200**	0.125	0.199**	0.234**	0.177*	0.318**	-0.334**	0.232**	0.141	0.162*	0.291**	0.246**	0.609**	1									
X15. Coordination	5.41	1.336	0.174*	0.193**	0.334**	0.412**	0.200**	0.241**	-0.098	0.123	0.162*	0.222**	0.201**	0.164*	0.674**	0.588**	1								
X16. Communication	4.58	1.197	0.153*	0.131	0.190**	0.227**	0.108	0.257**	-0.112	0.137	0.080	0.110	0.154*	0.189**	0.616**	0.465**	0.524**	1							
X17. Communication	5.81	1.268	0.200**	0.049	0.205**	0.204**	0.196**	0.194**	-0.250**	0.130	0.044	0.134	0.076	0.074	0.436**	0.464**	0.365**	0.491**	1						
X18. Communication	5.88	1.522	0.106	0.145*	0.226**	0.186*	0.122	0.152*	-0.065	0.042	0.040	0.102	0.047	0.040	0.332**	0.332**	0.387**	0.360**	0.462**	1					
Y1. Innovation output	5.13	1.410	0.009	0.101	0.133	0.150*	0.128	0.117	-0.028	0.153*	0.188**	0.226**	0.183*	0.169*	0.301**	0.293**	0.374**	0.214**	0.041	0.094	1				
Y2. Innovation output	5.47	1.031	0.216**	0.011	0.264**	0.326**	0.153*	0.230**	-0.167*	0.145*	0.214**	0.264**	0.238**	0.240**	0.389**	0.403**	0.382**	0.319**	0.227**	0.158*	0.380**	1			
Y3. Innovation output	3.98	1.518	0.090	-0.042	0.176*	0.289**	0.078	0.048	-0.040	0.019	0.096	0.097	-0.006	0.123	0.129	0.104	0.212**	0.141	-0.002	0.002	0.178*	0.319**	1		
Y4. Innovation output	5.34	1.065	0.103	0.031	0.230**	0.265**	0.247**	0.245**	-0.136	0.148*	0.264**	0.326**	0.291**	0.311**	0.320**	0.302**	0.332**	0.289**	0.107	0.012	0.440**	0.667**	0.427**	1	
Y5. Innovation output	65.32	32.785	0.022	0.044	0.047	0.184*	0.064	0.104	-0.006	0.061	0.053	0.034	0.058	0.056	0.168*	0.197**	0.233**	0.085	0.039	0.039	0.260**	0.289**	0.160*	0.310**	1

Table 3 The goodness of fit of the structural models.

MODELS	χ^2 Satorra-Bentler (gl)	p-value	GFI	AGFI	RMSEA	BBNNFI
H1	31.4706 (26)	0.21121	0.958	0.927	0.052	0.975
H2	72.0905 (61)	0.15660	0.938	0.908	0.031	0.977
H3	63.4301 (63)	0.46111	0.950	0.928	0.006	0.999
H4	61.0248 (49)	0.11631	0.939	0.902	0.036	0.969
H5	59.5129 (51)	0.19344	0.942	0.911	0.030	0.973

In accordance with recommended values: GFI: LISREL goodness of fit index ≥ 0.9; AGFI: LISREL adjusted goodness of fit index ≥ 0.9; RMSEA: Root mean square of approximation ≤ 0.08; BBNNFI: Bentler-Bonett non-normed fit index ≥ 0.9

Table 4 Estimated parameters in the structural models.

MODELS	Model 1 (H1)	Model 2 (H2)	Model 3 (H3)	Model 4 (H4)	Model 5 (H5)
γ_1 (t value)	**0.406** **(3.738)**	- 0.509	- 0.547	- 0.466	- 0.426
γ_2		- 0.340	- 0.281	- 0.397	- 0.439
γ_3 (t value)		**0.768** **(47.581)**	**0.746** **(37.394)**	**0. 777** **(57.596)**	**0.764** **(45.272)**