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THE ROLE OF INTELLECTUAL CAPITAL ASSETS ON THE RADICALNESS OF INNOVATION: DIRECT AND MODERATING EFFECTS

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ABSTRACT

This paper proposes a model on the radicalness of innovation from ‘An Intellectual Capital-Based View’, based on a sample of 251 Spanish technology-based manufacturing firms. Thus, we examine how human, organizational, technological, relational and social capitals influence incremental and radical innovations in different way. In general terms, results regarding direct effects show a greater positive influence of human capital on radical innovations than on incremental ones, being the opposite effect in the case of organizational, technological, relational and social capitals. And, taking into account the moderating effect of human capital on the relationship between relational capital and radical innovations, results show the importance of human capital when a firm tries to achieve a radical innovation by means of external relationships.

INTRODUCTION

Knowledge Economy (Grant, 1996; Dean and Kretschmer, 2007) is characterized by the economic globalization, advances of the technological domains, the progressive primacy of services sector, accelerated product cycles, and changes in the customer’s needs and preferences. Hence, a new competitive dynamic is appearing (Johnson, Neave and Pazderka, 2002; Leitner, 2005; Díaz-Díaz, Aguilar-Díaz and De Saá-Pérez, 2008), in which firms give increasingly importance to intangible resources and capabilities when they face competitors, recognizing that new knowledge and its effective implementation are key factors in achieving and maintaining competitive advantages (Galende, 2006). In this competitive arena, one of the best ways for reaching firm competitive advantage position comes directly from continuous technological innovations.

Thus, that new competitive dynamic leads us to pay attention to the technological innovations achievement as a key aspect for business success (Tushman and Nadler, 1986; Salman and Saives, 2005; Galende, 2006; O’Connor and DeMartino, 2006; Molina-Castillo and Munuera-Alemán, 2009; among others), using intangible resources and capabilities owned by a firm, that is, its intellectual capital. Concretely, Yam, Cheng, Fai and Tang (2004) state that technological innovation can entail positive impacts, increasing the competitiveness of a firm. So, if a firm tries to survive and thrive within that kind of environment it should be continuously updated (Danneels, 2002). This issue has been analyzed by several empirical studies, concluding a-priori that intangible factors owned by a firm -specific intellectual capital-, have a more significant influence on innovation results (Bowman and Helfat, 2001; Subramaniam and Youndt, 2005; Reed, Lubatkin and Srinivasan, 2006).

Therefore, it can be said that the innovative capability of a certain firm depends very closely on the intellectual assets and knowledge that it possesses, as well as on its ability to deploy them, viewing the innovation process as intensive knowledge management process (Nonaka and Takeuchi, 1995). Nevertheless, as Galende and De la Fuente (2003) point out, a good piece of research is devoted to address the innovation processes from an external perspective, leaving aside the internal complexity that characterizes the innovation dynamic. In this sense, even though the basic link between firm knowledge and innovation is on the whole so persuasive,

more remains to be understood about its precise and complex nature (Subramanian and Youndt, 2005).

Taking into account the previous arguments, during last decades some approaches have appeared in order to analyze that firm situation, as the Resource-Based View (RBV) (Barney, 1991) or the Knowledge-Based View of the Firm (KBV) (Kogut and Zander, 1992; Nonaka, 1994), highlighting the strategic role of intangible factors - they are knowledge in essence- for achieving sustained business success.

Nevertheless, these perspectives have some problems regarding conceptualize, assessment and measurement of intangible resources and capabilities. So, this study uses 'An Intellectual Capital-Based View' (ICV) trying to overcome some limitations of previous frameworks (Reed et al., 2006). Specifically, 'the RBV's lack of specificity have raised questions as to its status as a legitimate theory, and make it difficult to design and test empirically' (Reed et al., 2006: 868).

Therefore, due to intellectual capital requires comprehensive theoretical and empirical development, as well as the important role of technological innovation in firm success (Van de Ven, 1986; Galende, 2006); our research tries to examine the influence of each intellectual capital components on the radicalness of innovation.

In this sense, this work proposes a classification and measurement of intellectual capital, distinguishing five components (Human Capital, Organizational Capital, Technological Capital, Relational Capital, Social Capital), with the aim of explaining the radicalness of innovation from an Intellectual Capital point of view, owing to a lack of empirical studies that analyze it from that approach (as Subramaniam and Youndt, 2005; Wu, Lin and Hsu, 2007; among others). Specifically, we try to show the different importance of each intellectual capital components on a specific type of innovation: the radical/incremental ones or radicalness of innovation because it is one of the most relevance kinds of innovation in order to achieve business success (Song and Thieme, 2009, López-Cabrales, Cabello-Medina, Carmona-Lavado and Valle-Cabrera, 2008). Moreover, due to the current importance of relationships with external agents within the innovation process (Un, Cuervo-Cazurra and Anakawa, 2010), as well as the important role played by employees in order to absorb and assimilate new external knowledge, it makes necessary to analyse jointly human and relational capitals. Hence, we pay attention to the moderating effect of human capital between relational capital and radical innovation, since this kind of innovation enables the growth and renewal of a firm (O'Connor, 2008), which are key issues to compete within the current environmental.

The paper is structured as follows: section 2 provides a review on the existing literature in order to lay the theoretical foundations of the study, explaining its conceptual framework. In section 3 the model of analysis and hypotheses are shown. Section 4 presents the methodology followed by this research, describing the sample, measures of the variables, as well as their measurement properties. Section 5 shows the results from several lineal regression models. And, section 6 discusses the empirical results and some managerial implications are proposed, considering the limitations of this study.

THEORETICAL BACKGROUND

Intellectual capital

Although it has been recognized that economic wealth comes from knowledge assets -intellectual capital- and its useful application, replacing or perhaps supplementing land, labour, and capital (Dean and Kretschmer, 2007); the emphasis on this idea is

relatively new, and the management of a firm's intellectual capital has become one of the main tasks in the executive agenda. Nevertheless, this work is especially difficult because of the problems involved in its identification, measurement, and strategic assessment.

The term 'Intellectual Capital' is used as a synonym for intangible or knowledge assets (Stewart, 1991). On the basis of the proposal by Edvinsson and Malone (1997), intellectual capital is a two-level construct: human capital (the knowledge created by and stored in a firm's employees), and structural capital (the embodiment, empowerment, and supportive infrastructure of human capital). Then, they divide structural capital into organizational capital (knowledge created by and stored in a firm's information technology systems and process) and customer capital (the value of relationships between a firm and its customers). However, customer capital can be viewed as a key element of 'relational capital' (Bontis, 1996). So, from a sociological point of view, this relational capital encompasses all external relationships as a 'social capital' (Nahapiet and Ghoshal, 1998; Subramaniam and Youndt, 2005).

Despite the fact that there is no agreement among scholars about the concept, components, and variables of intellectual capital (Dean and Krestschmer, 2007), as a basic level, the conceptual separation of these IC aspects is evident from how each aspect accumulates and distributes knowledge and information differently: either through (i) individuals; (ii) organizational structures and/or processes, IT systems, and organizational technological knowledge; (iii) relationships and networks. In this sense, we propose as the main components of it (Bontis, 1996; Edvinsson and Malone, 1997; Subramaniam and Youndt, 2005; Erickson and Rothberg, 2009; Hsu and Fang, 2009): human capital, organizational capital, technological capital, relational capital, and social capital. In a wide sense, these issues represent different expressions of a firm's intangible resources and knowledge.

Human capital refers to the knowledge that employees possess as well as their ability to generate it, which is useful for the firm, and includes individual values and attitudes, aptitudes, and know-how (Subramaniam and Youndt, 2005). Nevertheless, although human brain can be considered as the main source of knowledge creation, an organization can accumulate, codify, and store individual knowledge in databases, proceedings, and organizational structures. Depending on the nature of this collective and structured knowledge, we could talk about organizational capital, which is referred to institutionalized knowledge and organizational mechanisms to integrate and transfer knowledge throughout the organization, and technological capital that refers to organizational technological knowledge. This split is due to the fact that both capitals are uneven in nature, have different strategic implications (CIC, 2001) and require different strategies for their accumulation and exploitation (Tseng y Goo, 2005).

Relational capital arises from relationships processes that a firm maintains with external agents that surround it (CIC, 2003; Reed et al., 2006; Hsu and Fang, 2009). As Acedo, Barroso and Galán (2006) highlight, relational capital or capabilities are an emerging theme in the fields of strategic management and industrial marketing. Relational capital gathers those intangible assets that a firm obtains when it maintains successful relationships with agents of its environment as customers, suppliers, or allies; hence, it refers to the establishment, maintenance, and development of relations, including aspects such as the degree of customer, supplier, and strategic partner satisfaction, as well as the merger of value and customer loyalty.

Finally, among the individuals and the formalized organizational structure of a firm, social capital can be defined as the knowledge embedded within, available through,

and utilized by interactions among individuals, working groups, and their networks of relationships (Nahapiet and Ghoshal, 1998), in a collective way, but without the formality and rigidity of organizational capital. In this study, due to different ideas and approaches around social capital (Adler and Kwon, 2002), we focus on sociological view (Fukuyama, 1997), understanding it as knowledge derived from informal and personal relationships among employees that are not predetermined by the company (Pennings, Lee and Van Witteloostuijn, 1998; Chow and Chan, 2008).

Radicalness of Innovation

As we have argued, innovation is the primary instrument of competition for many firms, especially in technology and knowledge-based industries. Generally speaking, the innovation process can be understood as a complex activity in which new knowledge is applied for commercial ends (Galende, 2006; Escribano, Fosfuri and Tribó, 2009). Innovation is generally viewed as one of the most important sources of sustainable competitive advantage because it leads to product improvements that increase the value of the product portfolio (Coombs and Bierly, 2006); helps firms survive; makes continuous advances (Liu, Chen, and Tsai, 2005); allows innovators to grow faster, being more (dynamically) efficient, and ultimately more profitable than non innovators (Mansury and Love, 2008). In fact, innovation has also been defined as the most knowledge-intensive organizational process that depends on a firm's individual members and collective knowledge (Adamides and Karacapilidis, 2006).

One of the most common ways of defining and classifying innovation involves its degree of novelty, from incremental to radical ones. Pavitt (1991) describes radical innovations as revolutionary or discontinuous changes, while incremental innovations are conventional or simple extensions in a line of historical improvements. Focusing on product innovation, Herrmann, Gassmann and Eisert (2007: 93) define 'radical product innovation as the propensity of a company to introduce new products that incorporate substantially different technology from existing products and can fulfill customer needs either significantly better than existing products, or address different types of needs which could not be fulfilled at all with existing products'.

In the current turbulent environment, with rapid technological changes, firms cannot rely on incremental innovations alone, they should sustain their competitive positions generating radical innovations as well (Lettl, 2007). In economic terms, radical innovations has a impact considerably more dramatic (Marvel and Lumpkin, 2007), constituting important drivers of the growth, success, and wealth of firms and nations (O'Connor, 2008; Tellis, Prabhu and Chandy, 2009), being that phenomenon more and more frequent even in very established industries (Castiaux, 2007). In this way, this investigation proposes the following hypotheses about the determinants of radicalness of innovation.

HYPOTHESES DEVELOPMENT

As we previously have commented, from a theoretical point of view (Nonaka and Takeuchi, 1995), a basic link between knowledge stocks and flows, and the innovation process exists (Díaz, Aguilar and De Saá, 2006). Nevertheless, only with a few exceptions (as Subramaniam and Youndt, 2005; or Wu, Chang and Chen, 2008), there is a scarcity of empirical investigations about the innovation process from 'An Intellectual Capital-Based View of the Firm'.

In this sense, although the value of tangible assets is generally recognized, managers need to know how their investments in intangible assets are associated to a firm's returns, and in our case, to innovation outputs (Wu et al., 2008).

From a theoretical perspective, it is widely acknowledged that intangible assets are a key source of competitive advantage and value creation (Barney, 1991; Galende, 2006). Specifically, firms belonging to technology and knowledge-based industries recognize intellectual capital as the major knowledge base which contributes to the creation of a competitive advantage for the firm (Ranjith-Appuhami, 2007). As Lettl (2007) highlights and understanding innovation as a potential source of competitive advantage, in order to develop radical innovations, firm relies on a set of different capabilities, as technological or market related ones. However, from an empirical point of view, and except for research as those of Subramaniam and Youndt (2005) or Smith and Sharif (2007), the researches that deal with this topic from the KBV and the ICV are quite scarce. As López-Cabrales et al. (2008) emphasize, the key role of intellectual capital has for firm's innovation capability remains to be understood about its precise nature.

Although the basic link between intellectual capital and firm innovation is on the whole persuasive, additional efforts for understanding this causal relation are worthwhile. Hence, we analyze innovation performance through its novelty degree, because this becomes necessary for a firm's survival, as well as sustained competitive advantage (Hsu and Fang, 2009).

In the next section we will try to develop the main hypotheses about the direct and moderating effects of human, organizational, technological, relational, and social capital on a firm's radical versus incremental innovation, considering consequently the degree of radicalness of innovation.

The direct effects of intellectual capital on radical and incremental innovations

Having brilliant, motivated, and experienced human capital should be the base for all innovation processes in a firm. This kind of intellectual capital provides the main source for developing new ideas and knowledge (Snell and Dean, 1992). Individuals and their associate human capital assets are crucial for exposing an organization to technology boundaries that increase their capacity to absorb and deploy new and substantially different knowledge domains (Subramaniam and Youndt, 2005). Highly motivated and trained employees may question the established organizational routines; hence, this kind of human capital becomes critical to push the firm to its technological borders, constituting the best incentive towards obtaining new knowledge and radical innovations (Nonaka and Takeuchi, 1995; Hill and Rothaermel, 2003).

In this sense, it makes sense to state that those firms with the best human capital will be able to create the highest number of new ideas and products, being human capital the main source for new ideas and knowledge helping in the development of radical innovations. The following hypothesis tries to short this argument.

H1: The firm's human capital endowments influence significantly and positively innovation, and will explain a higher extent of radical innovation than incremental one.

Beyond human capital, an important part of knowledge, abilities, experiences, and behaviours required for the successful development of new products and services lies inside and embedded thorough the organization. Furthermore, in order to get involved workers in the innovation process, the firm should develop support organizational mechanisms, infrastructure, governance, and so on (O'Connor and McDermott, 2004). As Van de Ven (1986) points out, the innovation process -in general terms- is a collective achievement of the organizational members, where organizational support becomes a key element. Institutionalization acts as a means for preserving

organizational knowledge and routines, which in turn fosters the accumulation, preservation, and improvement of collective knowledge.

Following López-Cabrales et al. (2008), by means of knowledge integration, the firm can recognize its knowledge base and learning, deciding how to use and deploy them. For Tseng and Goo (2005), a good structural capital will translate the human dimension of innovation into company property, through appropriate managerial leadership and ability. For doing so, firms must support and nurture the brightest individuals to share their innovation, knowledge, and abilities from organizational learning. Tacit issues like managerial commitment, a common identity and shared vision, or a climate of openness and experimentation compose the learning capability of a firm (Akgün, Keskin, Byrne and Aren, 2007).

In the empirical study of Herrmann et al. (2007), they found that organizational and cultural capabilities increase the propensity of an established firm to introduce radical innovations. Nevertheless, although organized information cannot substitute tacit knowledge, it can significantly enhance it to fill existing knowledge gaps; hence, information technologies can support the transformation of information into organizational knowledge (Adamides and Karacapilidis, 2006). In this vein, operational processes, information systems, organization culture, internal organizational structure, and administrative systems will have a positive influence on the incremental innovative capabilities of a firm.

In the same way, Subramaniam and Youndt (2005) found empirical evidence about the positive influence of structural capital -that includes organizational and technological ones- on incremental innovations. In their explanation, they assert that institutionalized knowledge accumulated and utilized through patents, databases, structures, systems, etc., helping its incremental innovative capabilities. Specifically, and paying attention to technological knowledge, in the meta-analysis carried out by Damanpour (1991:558), based on Deward and Dutton (1986), it is asserted that “the greater the technical knowledge resources, the more easily can new technical ideas be understood and procedures for the development and implementation be attained”, when he showed the relationships between organizational determinants and innovation. In this sense, subsequent studies (e.g. Adner, 2002; McEvily and Chakravarthy, 2002; Nerkar and Roberts, 2004; Rothaermel and Hill, 2005) stated that accumulated technological knowledge throughout the time by a firm will involve the development of path-dependence, achieving R&D capabilities as a key issue to attain better innovation results because they are important to understand and assimilate new technology, jointly R&D efforts and patents or licences. So, incremental innovation will be achieved from R&D intensity and R&D constant activities within a firm (Leiponen, 2006).

H2: The firm's organizational capital endowments influence significantly and positively innovation, and will explain a lower extent of radical innovation than incremental one.

H3: The firm's technological capital endowments influence significantly and positively innovation, and will explain a lower extent of radical innovation than incremental one.

Continuing with the direct effects of intellectual capital components on innovation outputs, the following one refers to the role of external sources of intangible assets. Relationships maintained by a firm with the different agents of its competitive environment (mainly customers, allies, suppliers, as well as other firms and institutions) or relational capital constitutes a good source of information and knowledge gathering for the firm learning and innovation (Tseng and Goo, 2005).

There is recognition of the key role of external knowledge on the innovation process within corporations, over past two decades (Escribano et al., 2009). The well-known Cohen and Levinthal's (1990) concept about 'absorptive capacity' -the firm's ability to recognize the value of new external knowledge, and then assimilate and utilize it for commercial ends- is largely based on the exposed concept of relational capital.

In fact, some researchers claim that most advances and newly sources of innovation are created within networks, being the locus of it in inter-organizational networks rather than in isolated firms (Wincen, Anokhin and Örtqvist, 2010). As Lettl (2007) remarks in his case study, deeper and closer relationships between the firm and specific users -as market related firm capability- benefit significantly for its radical innovation. Gaining innovation outputs from external sources has been recognized as a key mechanism to enhance radical innovations (Chesbrough and Teece, 2003). More specifically, Song and Di Benedetto (2008) highlight the essential role of supplier involvement in developing radical innovations.

Therefore, the value of these relationships needs to be understood and carefully managed, especially in the buyer-seller relationships (Baxter and Matear, 2004), being one of the most valuable intangible assets of a firm. For the case of radical innovations, relationships with users involved at the prototype stage to gain market first evaluations, lead to firm potential benefits in the development of new products and services (Lettl, 2007). In this sense, the traditional view of innovation through sequential linear models of push-and-pull technology has evolved into a conception that understands innovation as a multifactor process that requires high levels of interaction at the inter-firm level (Adamides and Karacapilidis, 2006).

In summary, external knowledge sources has been recognized as a key mechanism in obtaining innovations, especially in radical ones.

H4: The firm's relational capital endowments influence significantly and positively innovation, and will explain a higher extent of radical innovation than incremental one.

Social capital is considered as the new approach, which explains the success of innovation (Zheng, 2008). In general terms, firm's members make the creation of knowledge easier (Zupan y Kase, 2007). In this sense, social networks allow accessing to new resources, and provide relevant information (Herrera, 2009), being a key issue in order to achieve innovations, above all, when interactions among individuals are close (Huang and Li, 2009).

Thus, using a 'human side' of radical innovations, O'Connor and McDermott (2004) highlight the power and strategic role of informal networks -human face-to-face- for radical innovation success. In this sense, social capital may be critical for obtaining information and knowledge, solving problems, and identifying potential new applications, acting as a mechanism for managing the uncertainty of radical innovations. In the same line, Subramanian and Youndt (2005) empirically found an important role of social capital as a positive moderating effect between human capital and radical innovations, emphasizing that communication, fluid diffusion of information, and the sharing of knowledge are vital elements of innovative capabilities, being fundamental investments in social capital for developing a range of innovative capabilities. Furthermore, López-Cabrales et al. (2008) conclude that team cohesion, coordination, communication and mutual support are key aspects in developing radical innovations.

H5: The firm's social capital endowments influence significantly and positively innovation, and will explain a higher extent of radical innovation than incremental one.

The moderating effects of human capital on the relation between relational capital and radical innovation

Although literature suggests that closer relationships among a firm and its suppliers, allies, customers or users are an important source of new knowledge domains for developing radical innovations (e.g. Nieto and Santamaría, 2007; Song and Thieme, 2009), this relation may be moderated by the nature and structure of firm's employees.

The basic assumption of the well-known Cohen and Levinthal's (1990) 'absorptive capacity' highlights that a firm ability for assimilating external new knowledge may be determined in a positive way by the firm knowledge base –embedded in the organization as a whole as well as in its employees-. So, the assimilation of acquired knowledge is related to employees' absorptive capacity and capabilities, being important aspects within the knowledge transfer and exploitation processes in a firm. In this way, maybe several aspects of human capital studied in this work, as accumulated experience and abilities, education and training could play an incentive role in absorbing, using, assembling, interpreting external knowledge cogenerated with suppliers or users, for example, in order to develop radical innovations. Specifically, Subramaniam and Youndt (2005) analysed the interaction between human capital and social capital, finding a significant and positive influence radical innovative capability, including as institutional as personal relationships within social capital, whereas this study considers separately them. As far as, Soosay and Hyland (2008) highlighted absorptive capacity to assimilate knowledge and lead to the radical innovation achievement by means of human capital. In this sense, we propose the following hypothesis:

H6: The human capital moderates the relationship between the relational capital and radical innovation

METHODS

Sample

This research started from the SABI database¹ in order to determinate the population, obtaining a total number of 1270 firms. Within this population were included high and medium-high technology manufacturing Spanish firms with fifty or more employees, because this kind of firms has a strong dependence on intellectual capital, since they are based on knowledge (Johnson et al., 2002; Leitner, 2005), and because they have an adequate size to develop an enough amount of different knowledge blocks. In addition, according to Rouse and Daellenbach (1999), and King and Zeithaml (2003), it seems appropriate to consider firms belonging to a homogeneous industry to avoid different effects derived to environmental characteristics.

With the aim of collecting data, we designed a questionnaire (7-point Likert scale) because secondary sources do not provide enough information about the valuable and unique competences of a firm (Penrose, 1959). Thus, at June 2009, we obtained a sample of 251 firms, with a response rate of 17.07% and a sampling error of +/- 5.5%

¹ "Sistema de Análisis de Balances Ibéricos" (SABI) is an economic-financial database which incluyes around 550.000 Spanish firms and 67.000 Portuguese firms. Each record provides the following information: contact, activity description, national and international economic activities codes (in this article is used CNAE-93), corporate body, number of employees, profit and loss account, setting-up date, etc.

for a 95% of confidence level (see Table 1). Furthermore, top managers were the respondents, since they have a wider vision of their firms.

Table 1. Empirical Research Resume

<i>Target Population</i>	1270 high and medium-high technology manufacturing firms
<i>CNAE-93</i>	24, 29, 30, 31, 32, 33, 34, 35
<i>Firm Size</i>	50 or more employees
<i>Geographic Zone</i>	Spain
<i>Gathering Data</i>	questionnaire
<i>Sample Size</i>	251 valid questionnaire
<i>Response Rate</i>	17.07%
<i>Sampling Error</i>	+/- 5.5%
<i>Sampling Technique</i>	Random algorithm of Pascal's language
<i>Statistical Software</i>	SPSS 17.0 and AMOS 7.0
<i>Fieldwork</i>	From January to June 2009
<i>Respondents</i>	Top Managers

Measures

Regarding five intellectual capital components, *human capital* was assessed by four items referred to education and training (based on Snell and Dean, 1992; Zárraga and Bonache, 2005; Wu et al., 2008; among others) as well as experience and abilities (based on Subramaniam and Youndt, 2005; Reed et al., 2006; among others); *organizational capital* was measured with four items related to innovation culture (based on Carmeli and Tishler, 2004; Chen, Zhu and Xie, 2004; Subramaniam and Youndt, 2005; among others) and CEO commitment towards innovation (based on Carmeli and Tishler, 2004; Akgün, Byrne, Lynn and Keskin, 2007; among others); *technological capital* was measured with four items referred to internal R&D effort (based on Cohen and Levinthal, 1990; Tsai, 2001; Greve, 2003; Nieto and Quevedo, 2005; among others) and external R&D effort (based on Nieto and Quevedo, 2005; Subramaniam and Youndt, 2005; Egbetokun, Siyanbola, Sanni, Olamide, Adeniyi, and Irefin, 2009; among others); *relational capital* was assessed by six items related to relationships with customers, suppliers, and allies (based on Chen et al, 2004; Subramaniam and Youndt, 2005; Reed et al., 2006; among others) and; *social capital* was measured with four items referred to individual social network (based on Wu et al., 2008; among others), shared vision (based on Chow and Chan, 2008) as well as confidence and social support among employees (based on Rodan and Galunic, 2004; Zárraga and Bonache, 2005).

With respect to dependent variables, *radical innovation* was measured with three items related to number of new completely innovations developed by a firm (Li and Atuahene-Gima, 2002; Souitaris, 2002; Govindarajan and Kopalle, 2006; among others), obsolescence of previous innovations (Subramaniam and Youndt, 2005; Molina-Castillo and Munuera-Alemán, 2009), and percentage of sales on radical innovations (Souitaris, 2002; Chen et al., 2004; among others); and *incremental innovation* was also assessed with three items referred to number of innovations with significant changes and improvements developed by a firm (Li and Atuahene-Gima, 2002; Souitaris, 2002; Wu et al., 2008; among others), reinforcement of previous

innovations (Subramaniam and Youndt, 2005) and percentage of sales on incremental innovations (Souitaris, 2002; Chen et al., 2004; among others), with the aim of assessing the output's level regarding radical and incremental innovation developed by a firm.

Finally, due to the fact that a firm's size and age, as well as sector to which a firm belongs may influence the innovation development carried out by a firm; they are considered as control variables (based on Tsai, 2001; Greve, 2003; Li and Atuahene-Gima, 2002; Subramaniam and Youndt, 2005; Reed et al., 2006; Batjargal, 2007; among others). Size was measured by means of employees who belong to the firm; age was measured from the firm's establishment; and regarding sector, they were taken into account, on the one hand, high technology manufacturing firms, and, on the other hand, medium-high technology manufacturing firms.

Measurement Properties

First of all, an exploratory factor analysis was conducted, including all items related to intellectual capital components. Using varimax orthogonal rotation, five factors were obtained, which are referred to the five components theoretically considered (see Appendix). The main indexes shown the convenience of carrying out this kind of analysis (Hair, Anderson, Tatham and Black, 2004), since the KMO index had a value higher than .7 (.897); the Bartlett's test was significant a level less than .05 (.000); and the matrix determinant value had a close value to 0 (6.91 E -006). Moreover, all items had a load close or higher than .6, and were included on the right factor, except HC4 (item referred to employee valuable abilities), which had a high load to the factor 2 (SC), but taking into account the academic literature, this issue is included on human capital. And, the percentage of intellectual capital explained variance was 64.873.

In addition, Cronbach's alpha coefficients for each intellectual capital factor were close or higher than .7 (Hair et al., 2004), as well as for all items of each of them; obtaining .642 for human capital factor, .868 for organizational capital factor, .772 for technological capital factor, .863 for relational capital factor, .880 for social capital factor, and .751 for all items of intellectual capital components. So, utilized measures are internally consistent.

The next step was a confirmatory factor analysis using AMOS 7.0, and the results suggested that the intellectual capital model provided a moderate fit for the data, since chi-squares/degrees of freedom ratio was less than 3 ($\chi^2/df = 2.415$); GFI (Goodness of Fit Index), AGFI (Adjusted Goodness of Fit Index), IFI (Incremental Fit Index), and CFI (Comparative Fit Index) were close to .9 (Bentler and Bonett, 1980), obtaining GFI = .846; AGFI = .804; IFI = .898; and CFI = .897; and RMSEA (Root Mean Square Error of Approximation) was less than .08 (Browne and Cudeck, 1993), obtaining RMSEA = .075. However, a second analysis was performed allowing a covariance between the errors (Byrne, 2001) from items RC5 and RC6; HC2 and HC1; TC2 and TC1; TC4 and SC1; TC2 and RC4, based on a modification index and content overlap of those items. The fit indexes of this second model showed a better fit of the data, obtaining $\chi^2/df = 1.749$; GFI = .887; AGFI = .853; IFI = .948; and CFI = .947; and RMSEA = .055.

Then, other exploratory factor analyses were executed in order to develop the variable "radical innovation" and "incremental innovation", finding that the three items of each one of them had a high load (over .7). And, regarding main indexes, their KMO indexes had a close value to .7 (.631 and .735, respectively); both Bartlett's tests were significant a level less than .05 (.000); and the matrix determinant values had a close value to 0 (.334 and .177, respectively). Furthermore, the percentages of radical and

incremental innovation explained variance were 70.959 and 81.635; and Cronbach's alpha coefficients were .793 and .887, showing internally consistent.

Table 2 provides descriptive statistics and correlations across the variables. Multicollinearity was tested and it did not appear to be a problem as the observed highest value of the variance inflation factors (VIFs) was 2.156 for organizational capital.

Table 2. Correlations

	Mean	SD	1	2	3	4	5	6	7	8	9	10
1. Size Logarithm	2.05	.317	1									
2. Age	25.51	15.33	.086	1								
3. Sector	.171	.378	-.037	-.030	1							
4. Human Capital	20.68	3.34	.054	-.006	.124*	1						
5. Organizational Capital	21.39	4.66	.081	-.056	.019	.524**	1					
6. Technological Capital	17.87	5.82	.159*	.116	.166**	.401**	.527**	1				
7. Relational Capital	31.88	6.69	.044	.035	.037	.459**	.534**	.458**	1			
8. Social Capital	22.86	4.35	.095	-.075	.000	.435**	.618**	.421**	.508**	1		
9. Radical Innovation	13.88	3.87	.007	.025	.044	.521**	.546**	.550**	.477**	.407**	1	
10. Incremental Innovation	14.77	4.06	-.010	.066	.070	.511**	.583**	.576**	.506**	.455**	.864**	1

*. Correlation is significant at the 0,05 level (bilateral).

** . Correlation is significant at the 0,01 level (bilateral).

RESULTS

In order to test the hypotheses, this study used multiple lineal regression analysis through SPSS 17.0, examining before the normality of dependent variables by means of Q-Q graph as well as Kolmogorov-Smirnov test, obtaining satisfactory outputs. In addition, according to multiple lineal regression rules, Durbin-Watson's values were close to 2, so residues are independent, and statistician F values shown a linear significant relation among radical innovation/incremental innovation and each of intellectual capital components, showing the statistical validity of the proposed models.

As it can be seen (see Table 3 and Table 4), all intellectual capital components are positively and significantly related to radical innovation as well as incremental innovation (models 1-5 and 1'-5'). In addition, when they are considered jointly, with the aim of analyzing intellectual capital as a whole (models 6 and 6'), have also influence on radical innovation and incremental innovation.

Table 3. Results of Regression Analyses on Radical Innovation

VARIABLES	RADICAL INNOVATION						
	Model 1 (H1)	Model 2 (H2)	Model 3 (H3)	Model 4 (H4)	Model 5 (H5)	Model 6 (Intellectual Capital)	Model 7 (H6)
Human Capital (HC)	.336*** (5.498)					.341*** (7.169)	.388*** (6.625)
Organizational Capital (OC)		.305*** (4.986)				.294*** (6.217)	
Technological Capital (TC)			.382*** (6.241)			.389*** (8.010)	
Relational Capital (RC)				.293*** (4.808)		.295*** (6.286)	.297*** (5.104)
Social Capital (SC)					.209*** (3.334)	.206*** (4.375)	
RC*HC							-.087* (-1.679)
SizeLog	.011 (.174)	-.016 (-.270)	-.054 (-.890)	.008 (.133)	-.006 (-.100)	-.078 (-1.626)	-.028 (-.549)
Age	.022 (.369)	.056 (.0918)	-.020 (-.337)	.016 (.263)	.052 (.834)	.003 (.065)	.022 (.419)
Sector	-.016 (-.260)	.071 (1.157)	-.018 (-.308)	.037 (.614)	.045 (.729)	-.057 (-1.171)	-.023 (-.438)
MODEL RESUME							
Adjusted R ²	.097	.080	.125	.074	.030	.452	.336
T. Mistake	.9500	.9594	.9354	.9625	.9847	.7405	3.153
Durbin-Watson	2.084	2.176	2.088	2.052	2.146	1.980	1.983
F	7.747***	6.402***	9.933***	5.964***	2.956**	26.737***	22.069***

Significance level ***p<0.01 **p<0.05 *p<0.10 (t)

Table 4. Results of Regression Analyses on Incremental Innovation

VARIABLES	INCREMENTAL INNOVATION					
	Model 1' (H1)	Model 2' (H2)	Model 3' (H3)	Model 4' (H4)	Model 5' (H5)	Model 6' (Intellectual Capital)
Human Capital (HC)	.308*** (5.014)					.313*** (6.847)
Organizational Capital (OC)		.328*** (5.411)				.317*** (6.978)
Technological Capital (TC)			.394*** (6.496)			.399*** (8.562)
Relational Capital (RC)				.307*** (5.084)		.309*** (6.846)
Social Capital (SC)					.255*** (4.122)	.252*** (5.565)
SizeLog	-.009 (-.141)	-.037 (-.608)	-.074 (-1.242)	-.010 (-.171)	-.027 (-.443)	-.102** (-2.230)
Age	.063 (1.030)	.098 (1.615)	.018 (.300)	.055 (.907)	.097 (1.564)	.048 (1.044)
Sector	.017 (.276)	.101* (1.668)	.008 (.127)	.065 (1.078)	.074 (1.203)	-.023 (-.499)
MODEL RESUME						
Adjusted R ²	.087	.101	.141	.089	.059	.494
T. Mistake	.9555	.9483	.9268	.9543	.9702	.7116
Durbin-Watson	2.125	2.236	2.184	2.148	2.195	2.127
F	6.953***	7.999***	11.260***	7.130***	4.895***	31.468***

Significance level ***p<0.01 **p<0.05 *p<0.10 (t)

Nevertheless, it is necessary to pay attention to adjusted R² in order to test the formulated hypotheses. First, it will be taken into account to the three hypotheses that consider those intellectual capital components that may explain a higher extent of radical innovation. In this sense, regarding human capital ($\beta = .336$, $p < .01$), it can be asserted that the hypothesis 1 (model 1) is supported because the adjusted R² shows a greater value (.097) than in the model 1' (.087), explaining a higher portion of variance in variable "radical innovation". On the other hand, with respect to relational capital ($\beta = .293$, $p < .01$), and social capital ($\beta = .209$, $p < .01$), the hypotheses 4 (model 4) and 5 (model 5) are not supported, respectively, since the adjusted R² have a lower value (.074; .030) than in the model 4' and 5' (.089; .059), so these intellectual capital components explain a higher portion of variance in variable "incremental innovation" than "radical innovation".

Second, with regard to those hypotheses referred to a higher influence on incremental innovation, the hypothesis 2, and 3 are supported because the model 2', and 3', which consider to organizational capital ($\beta = .328$, $p < .01$), and technological capital ($\beta = .394$, $p < .01$), respectively, show a higher adjusted R² (.101; .141) than in the models 2, and 3 (.08; .125), explaining each one of them a greater portion of variance in the variable "incremental innovation" than in "radical innovation".

Regarding the models 6 and 6', in which intellectual capital is considered as a whole, it is also interesting to highlight the relevance increase of adjusted R², since intellectual capital components collectively explain an important portion of variance in as radical as incremental innovation, obtaining 45.2% and 49.4%, respectively.

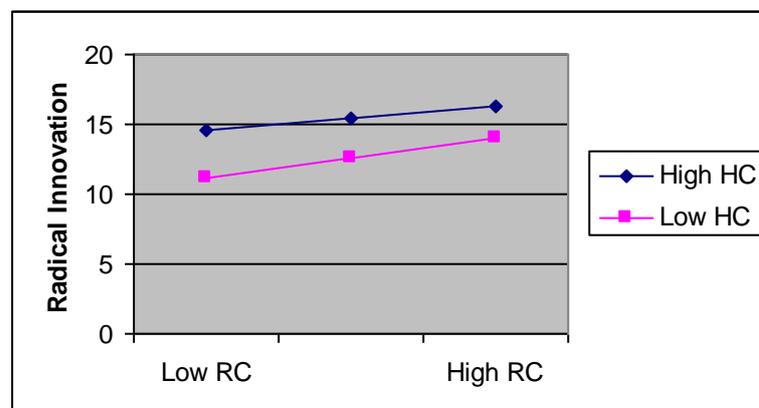
With respect to control variables, they do not have significant effects on radical innovation and within regression analyses on incremental innovation only variable “sector” in model 2’ and variable “sizelog” in model 6’ show significant effects.

Focusing on interaction between human capital and relational capital (model 7), the results show that both dimensions maintain individually a positive and significant influence on radical innovation; and have a significant relationships with that kind of innovation ($\beta = -.087$, $p < .10$) when their interaction is considered. So, it can be asserted that hypothesis 6 is supported. Figure 1 displays a plot of this interaction effect, in which is shown how human capital moderates the effects of relational capital on radical innovation.

Therefore, using Baron and Kenny’s (1986) criteria, the findings indicate that when human capital is low there is a significant relationship between relational capital and radical innovation (coefficient = .373; $t = 5.167$; $p < .01$), ranging scores on radical innovation from 11.90 when relational capital is low to 13.98 when it is high. And, in the same way, when human capital is high, that relationship is significant as well (coefficient = .222; $t = 2.962$; $p < .01$), varying scores on radical innovation from 14.63 when relational capital is low to 16.35 when it is high.

Furthermore, the adjusted R^2 (33.6%) is highly greater than individual adjusted R^2 related to human and relational capital (9.7% and 7.4%, respectively). Finally, on the same way previous models, control variables do not have significant effects on radical innovation.

Figure 1. The moderation of the effect of relational capital on radical innovation, by human capital.



CONCLUSIONS

Discussion

As it has been explained, even though the existing literature on the degree of radicalness of innovation, determining the organizational characteristics that predict radical and incremental innovation, empirical research remains scarce (López-Cabrales et al., 2008). In this sense, this study has tried to establish the sources of incremental and radical innovations from ‘An Intellectual Capital- Based View’.

Hence, three of raised premises have been strongly supported, showing that human capital seems to explain a higher extent of radical innovation than incremental innovation, and as organizational capital as technological capital appear to explain a higher extent of incremental innovation than radical innovation. However, relational

capital and social capital seem to explain a higher extent of incremental innovation than radical innovation, showing opposite results what it was expected.

Thus, paying attention to explanatory power that different intellectual capital blocks have on each type of innovation, this study contributes empirically to highlight their important role within radical innovation or incremental innovation, in spite of all of them play a relevant role on both kind of innovation because they have a positive and significant influence on radical and incremental innovation.

First of all, this research has found human capital has a positive relationship with radical innovation, contrary to what Subramaniam and Youndt (2005) found in their analysis. Therefore, according to Deward and Dutton (1986), human capital investments may mean an advantage on the radical innovation adoption, derived to the depth of knowledge resources. Specifically, human capital attributes of individuals who recognize and exploit opportunities enable them to generate the breakthrough insights that lead to radical innovation, being more likely that those who perceive a greater variety of opportunities select a more radical opportunity from the opportunity set (Marvel and Lumpkin, 2007). Nevertheless, there is a positive and significant influence on incremental innovation, concluding that human capital could play a key role within the development of technological innovation (both incremental and radical) for the firm, as Snell and Dean (1992) said.

Second, as expected, structured collective knowledge, represented by organizational capital and technological capital, positively influences incremental innovation more than radical one, supporting Subramaniam and Youndt's results (2005), and thereby showing that institutional knowledge reinforces existing knowledge used by a firm. Specifically, our analysis pays attention to innovation culture and CEO commitment towards innovation within organization capital. In this sense, our finding is contrary to what Deward and Dutton (1986) found, since they showed that managerial attitudes toward change are associated to adoption neither radical innovation nor incremental innovation, which may be related to whether management retains the power to make adoption decisions.

On the other hand, regarding technological capital, it has the highest explanatory power of all intellectual capital components on incremental innovation. This finding can be explained by the fact that aspects related to R&D efforts, as R&D expenditure, formalized R&D department, licenses, and patents utilization, that is, the firm technological knowledge base, add value in order to improve the new product and/or process develop from existing knowledge, based on the firm's path-dependence trajectory.

Third, this research has found that relational capital positively influences radical innovation, appearing to indicate that interactions with clients, suppliers and allies are important in order to enhance the firm's capacity of radical innovation development, according to Damanpour (1991), Nieto and Santamaría (2007), and Song and Thieme (2009). These authors highlight that those relationships are an important source of information to get new knowledge, and, therefore, develop new ideas. It is due to the fact that they provide resources as capabilities, information, knowledge or ideas, working together and sharing responsibilities within the innovation process (Van Echtelt, Wynstra, Van Weele and Duysters, 2008). In addition, it is important to take into account that those relationships can contribute with supplementary knowledge, improving innovative performance (Knudsen, 2007).

However, the results appear to show that relational capital plays a greater role when a firm focuses on incremental innovation, contrary to what we were expected. In this sense, it seems to maintain external relationships lead to improve existing knowledge

owned by a firm instead of entailing completely new knowledge. It is can be due to the fact that firms without a high degree of absorptive capacity will find difficulties to internalize their partners' knowledge (Tsai, 2009), which will be able to have even more a greater effect when that knowledge involves radical changes within the firm.

Fourth, social capital appears to have a higher influence on incremental innovation than radical innovation, unlike what we were expected. In this sense, personal and informal interrelationships among employees, which mean sharing their knowledge and experiences, exchanging ideas and information, and helping each other, may contribute to obtain better outputs in the firm from a viewpoint of improving in product and process innovation. This finding sheds light -from an empirical point of view- on arguments asserted by Bouty (2000), Moran (2005), Swart (2006), Wu et al. (2008) or Zheng (2008), who explain the relevance of social capital on innovation process. Furthermore, although Subramaniam and Youndt (2005) also contributed with empirical data on this matter, they considered jointly institutional and personal relationships. In this sense, this study specifically shows that personal and informal interrelationships among employees could play an important role on incremental innovation.

Finally, as expected, regarding the interaction of human capital and relational capital, this research has found a significant influence on radical innovation, appearing to show that human capital moderates the relationships between relational capital and radical innovation. In this sense, as we have appointed, when a company maintains deeper relationships with its customers, suppliers, alliance partners, and so on, it will be advisable a high human capital in order to achieve breaking-nature innovations, since those employees with accumulated experience and abilities, education and training will be able to learn or use new knowledge. So, our results support arguments suggested by Soosay and Hyland (2008), showing the importance of employees' absorptive capacity to assimilate external new knowledge with the aim of attaining radical innovations when a firm maintains external relationships.

Managerial Implications

Owing to the fact that achieved radicalness of innovation depends on different resources, competences, capabilities or enablers (O'Connor and McDermott, 2004; Herrmann et al., 2007), it seems interesting that managers pay attention to possible sources through which can achieve a radical innovation or incremental innovation. This issue is especially relevant when a firm attempts getting radical innovations, on account of the difficulty to implement it.

Therefore, on the one hand, it is necessary to know how assess intangible factors (Kaplan and Norton, 2004) in order to be able to estimate their value; and, on the other hand, managers need guidelines regarding a specific knowledge base when they decide to carry out a radical or incremental innovation process, specifically, in high and medium-high technology manufacturing firms.

In this sense, this study contributes with a measurement scale to facilitate intangible factors assessment; and shows the different explanation powers of each intellectual capital component on radical and incremental innovation, so managers can make a suitable decision about investment to make in those intangible factors according to results that they expect to get in the Spanish context. So, from empirical evidence supported by this study, managers can get an idea about those intellectual capital configurations, which are more appropriate in order to achieve a radical innovation or incremental innovation.

Limitations of the study

The main limitations of the present research are the following ones: the first of them comes from the use of a Likert scale questionnaire, which involves the risk of subjective answers from respondents. However, this method has been applied in many studies to measure intangible resources because ad-hoc questions are more suitable in order to collect aspects closer to a specific and internal phenomenon, unlike proxies obtained from databases.

Second, it is interesting to emphasize that the findings of this empirical research can not be generalized for any kind of industry, since our sample is only referred to high and medium-high technology manufacturing sectors. For this reason, implications for managerial practice can only be obtained for these sectors. However, our population and sample were framed following the recommendations of Rouse and Daellenbach (1999), because according to the industrial setting and activities, knowledge needs and usage can be different (Roos and Roos, 1997; Rouse and Daellenbach, 1999). So, this consequence it would especially be an applicable issue within services sectors.

Finally, neither the dynamism of factors that affect firms has been taken into account nor how the change by firms as time goes by. This is a consequence of using a cross-sectional survey instead of carrying out a longitudinal study.

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Appendix: Questionnaire items (7-point Likert scale: 1 “strongly disagree”; 7 “strongly agree”)

Human Capital

- In my company, the percentage of people who receives training is higher than my competitors
- In my company, the percentage of people with superior a degree (bachelor, engineer, masters, etc.) is higher than my competitors
- The experience our employees have is appropriate to carry out their work satisfactorily
- Our employees have abilities that are widely considered to the best in our industry

Organizational Capital

- My company encourages creativity, innovation and/or the development of new ideas
- A common system of values, beliefs and objectives exists in my company, directed towards innovation
- Often, managers involve employees in important decision-making processes
- In my company, managers support and lead the innovation process

Technological Capital

- In my company, the average of R&D costs with respect to sales is one of highest in the industry
- My company has a formalized R&D department
- In my company, the average of purchase technology and/or licences is one of highest in the industry
- My company uses patents in order to accumulate knowledge

Relational Capital

- Employees of my company work jointly with customers to develop solutions
- The customer base of my company is one of the best in our industry
- Employees of my company work jointly with suppliers in order to develop solutions
- The supplier base of my company is one of the best in our industry
- Employees of my company work jointly with allies in order to develop solutions
- The allies base of my company is one of the best in our industry

Social Capital

- In my company, there are employees and/or teams who build informal network relationships in order to exchange idea and information about new product development
- In my company, there are employees and/or teams who agree on what is important at work
- In my company, there are employees and/or teams who are not reluctant to share their knowledge and experience
- In my company, there are employees and/or teams who help each other in order to generate new ideas and/or enhance your ability to do your daily job

Radical Innovation

- In general, the number of completely new innovations developed by my company in the last three years is higher than my competitors' one.

- My company develops innovations that turn into obsolete or drastically change prevailing/existing ones.
- The percentage of sales on radical innovations (completely new) introduced in the last three years is higher than my competitors' one.

Incremental Innovation

- In general, the number of innovations with significant changes and improvements developed by my company in the last three years is higher than my competitors' one.
- My company develops innovations that reinforce prevailing/existing ones.
- The percentage of sales on incremental innovations (with significant changes and improvements) introduced in the last three years is higher than my competitors' one.