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Intellectual capital and radical innovation: Exploring the quadratic effects in technology-based manufacturing firms ☆

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ABSTRACT

After two decades of research, the complex question of the link between intellectual capital and radical innovation remains unsolved. With the aim of shedding new light on the accumulation patterns of intellectual capital in its relationship with radical innovation, this paper develops a novel theoretical and empirical exploration of the quadratic effects of intellectual capital, both individually and collectively and internal and external to the firm, on radical innovations, from the perspective of the Intellectual Capital-Based View. Three main hypotheses considering the quadratic effects of human, technological and vertical social capital on radical innovation are presented. The results from a sample of 251 Spanish high and medium high-tech manufacturing firms show different accumulation patterns of technological and vertical social capital on radical innovation. While the technological capital-radical innovation link loses intensity once a certain endowment of technological capital is reached, the relationship between vertical social capital and radical innovation increases exponentially and grows more intensively once a certain endowment of vertical social capital is attained. Conversely, the relationship between human capital and radical innovation is linear and positive. In addition, firms belonging to the chemical industry also have a positive influence on radical innovation, revealing the importance of this industry regarding innovations and technical changes. This study contributes to the intellectual capital literature by providing new evidence that helps to clarify the curvilinear intellectual capital-radical innovation relationship and the different role that the three types of intellectual capital play in that relationship.

1. Introduction

This research responds to the unsolved question of the link between intellectual capital and radical innovations. To this end, the authors develop a new theoretical model that is empirically tested in technology-based manufacturing firms and offer new insights into the role and accumulation patterns of intellectual capital in the emergence of these types of innovations.

Today, intellectual assets – or intellectual capital in the Intellectual Capital-Based View (ICBV) – are key production factors in the global competitive arena (Dean, Kretschmer, 2007) and can be understood as the sum of all knowledge assets that firms use to attain a competitive advantage (Nahapiet and Ghoshal, 1998; Subramaniam and Youndt, 2005; Kang and Snell, 2009).

Intellectual capital drives firm adaptation, survival and success in constantly evolving markets (Stieglitz and Heine, 2007) and is a key factor of firm competitiveness in a knowledge-based economy (Tseng and Goo, 2005). In the current environment, which is characterized by the development of innovations with a very high degree of novelty (Benner and Tushman, 2003; Jansen, Van den Bosch and Volberda, 2006), intellectual capital constitutes a key source of radical innovation because in addition to being productively incorporated into firms' activities, it also implies the development of highly novel or unique products/services or production processes and the associated organizational competencies (Nonaka and Takeuchi, 1995; Tidd, 2001; Benner and Tushman, 2003) that rest upon the human capital embodied in organizational members, as well as other forms of collective knowledge embedded in the organization as a whole, such as technical know-how or technological capital, and knowledge derived from and embedded in external relationships among the firm members and its customers and suppliers.

Among technological innovations, radical innovations are those that require special attention in the current dynamic and

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constantly changing environment. Changes in the success factors of new product development have emerged (Evanschitzky, Eisend, Calantone and Jiang, 2012), and the importance of avoiding product obsolescence has pushed firms to focus on innovations with a high degree of novelty (Benner and Tushman, 2003; Jansen et al., 2006).

In this sense, despite the variety of contributions that have empirically analyzed the linear link between intellectual capital and radical innovation (i.e., Tsai and Ghoshal, 1998; Hayton, 2005; Leiponen, 2006; Subramaniam and Youndt, 2005; Díaz-Díaz, Aguiar-Díaz and De Saá-Pérez, 2006; Nieto and Santamaría, 2007; Song and Thieme, 2009; Zhou and Li, 2012), the literature on the topic of the non-linear accumulation patterns of the intellectual capital components in the intellectual capital-radical innovation relationship is quite scarce. This evidence clearly shows that the academic debate is still fairly nuanced and that the intellectual capital-radical innovation link constitutes a complex phenomenon that requires additional work to be understood (Subramaniam and Youndt, 2005; De Luca and Atuhaene-Gima, 2007; Zhou and Li, 2012).

Therefore, the primary goal of this study is to theoretically and empirically explore the quadratic effects and accumulation patterns of intellectual capital, both individually and collectively and internal and external to the firm, on radical innovations, from the Intellectual Capital-Based View perspective (Subramaniam and Youndt, 2005; Reed et al., 2006).

The authors make the following contributions to the literature on the intellectual capital-radical innovation link: first, an empirical analysis is performed of the little-addressed non-linear relationships between intellectual capital and radical innovation using a more comprehensive measure of radical innovation. In doing so, additional evidence is provided to clarify the inconclusive results – the knowledge base as a driver or inhibitor of innovation – derived from previous empirical contributions (i.e., Tripsas and Gavetti, 2000; Zahra and George, 2002) that analyze other non-linear and less specific relationships between intellectual capital and innovation performance (Katila and Ahuja, 2002; Laursen and Salter, 2006; Grimpe and Kaiser, 2010; Zhou and Wu, 2010; Chen, Chen and Vanhaverbeke, 2011).

Second, going beyond the technological knowledge base (Schoenmakers and Duysters, 2010), the authors delimit and identify the specific role played by each type of intellectual capital in its relationship with radical innovation. Thus, empirical evidence demonstrates that the achievement of such a degree of innovation novelty can follow a different development process depending on what type of intellectual capital the firm is handling (Grimpe and Kaiser, 2010; Cabello-Medina et al., 2011).

The remainder of the paper is structured as follows. Section two offers a literature review on the theoretical framework (ICBV) used in this research and on the variables considered in this empirical study (human, technological, vertical social capital and radical innovation). Section three presents the hypotheses to be tested. The measurement of the variables and the methodology to carry out the empirical analysis are described in section four. Next, the empirical findings using data from 251 Spanish high and medium-high tech firms are discussed in section five. The paper concludes with a discussion of the results, implications, and future research directions in sections six and seven.

2. Theoretical background

For more than two decades, firms' endogenous factors were considered to be key drivers of firms' competitive advantages (Wernerfelt, 1984; Barney, 1986; Rumelt, 1991). Specifically, there was a consensus among Resource-Based View (RBV) scholars (Barney, 1991; Grant, 1991; Amit and Schoemaker, 1993; Hall, 1993) in signaling intangible factors based on knowledge and information as the determinants of firm-sustained competitive advantage and even firm innovation (Newbert, 2008).

Nevertheless, those intangible resources and capabilities or, in other words, intellectual or knowledge assets, have proven to be problematic in terms of identification and measurement from RBV (Priem and Butler, 2001; Reed et al., 2006). To overcome these difficulties, the Intellectual Capital-based View (ICBV) has emerged as a more suitable theoretical approach (Reed et al., 2006; Martín-de Castro et al., 2013). From this perspective, knowledge assets and intellectual assets are called intellectual capital and can be considered to be equivalent (Steward, 1998; Subramaniam and Youndt, 2005).

Thus, following this theoretical approach, this work argues that firms' intellectual capital, which is accumulated through several levels within firms, namely, the individual, organizational, and inter-organizational, can be considered to be the determinant of radical innovations.

Given the persuasive nature of the intellectual capital-innovation link (Nonaka and Takeuchi, 1995) and the key role played by intellectual capital more generally in innovation development and creation (Grant, 1996), some scholars have devoted great efforts to disentangling the potential connections between these constructs. In particular, previous research has highlighted the role of intellectual capital as a driver of radical innovation capabilities, with each type of intellectual capital (human, structural and social) having its own accumulation pattern and effect on radical innovations (Subramaniam and Youndt, 2005). In this sense, it is worth noting that achieving radical innovations requires the involvement of types of knowledge assets that go beyond technological capital, as Schoenmakers and Duysters (2010) suggest.

Intellectual capital can be seen as the sum of all knowledge assets that firms use to achieve a competitive advantage (Nahapiet and Ghoshal, 1998; Subramaniam and Youndt, 2005; Kang and Snell, 2009), and there is some consensus about its key constituencies (Edvinsson and Malone, 1999): human capital, structural capital and social capital.

Human capital has been considered to be the cornerstone of the rest of the components of intellectual capital (Moon and Kym, 2006; Wu, Lin and Hsu, 2007). It is referred to as individual knowledge, both tacit and explicit, that is owned by a firm's employees, including experience, abilities, learning abilities or knowledge creation abilities (Brooking, 1996; Edvinsson and Malone, 1999; Youndt, Subramaniam and Snell, 2004). Human capital makes a firm's development possible, as knowledge-based organizations depend on each employee's ideas and know-how (Chan and Mauborgne, 2003). Therefore, human capital can be defined as employees' individual knowledge and abilities that are useful to carry out firms' activities.

Structural capital is a broad concept that includes the sum of all types of collective knowledge within a firm. It is the knowledge that remains in the organization when people depart (Edvinsson and Malone, 1999) and makes the firm's operations possible (Brooking, 1996). Following Subramaniam and Youndt (2005), structural capital is the institutionalized knowledge and codified experience residing within a firm and is utilized through databases, patents, manuals, structures, systems, and so on. All of these approaches to structural capital, however, encompass a wide variety of collective knowledge of different natures that have different implications for firms. In this sense, following Brooking (1996), this article differentiates within the concept of structural capital between organizational capital (which refers to firms' management and administrative processes) and technological capital (which refers to firm's technological developments and technological investment efforts). Although this breakdown in