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Social Processes of Knowledge of Technological Capabilities and Intellectual Capital on New Technology-Based Firms

Mónica Longo-Somoza ^α, Eduardo Bueno ^σ & Julio César Acosta-Prado ^ρ

Abstract- This paper proposes that social processes of knowledge developed by innovative firms are core factors of Technological Capability and Technological Capital, they are the same processes and they are also a critical key to get competitive sustainable advantages. From the Resource-Based View approach, the Dynamics Capabilities approach and the Knowledge-Based Theory of the firm, the importance of knowledge as a key ingredient of technology must be emphasized and its importance to find the way back to the economic growth. We investigate that when the members of an innovative firm create and develop their firm's Technological Capabilities, using social processes of knowledge, they are also creating and exploiting the firm's Intellectual Capital. This proposition is grounded in the theoretical proposal of a definition and classification of Technological Capabilities, and a proposal about the relationship between Technological Capabilities and Intellectual Capital, specifically the Technological Capital. We also propose that the social processes of knowledge are the core of this relationship. The empirical study was conducted using a multiple-case study methodology in 35 New-Technology-Based Firms (NTBFs) of the Madrid Scientific Park (PCM) and the Leganés Science Park (LEGATEC), in the Community of Madrid, Spain.

Keywords: *intellectual capital, new-technology-based firms, social processes of knowledge, technological capital, technological capability.*

1. INTRODUCTION

Nowadays the processes of creating and exploiting knowledge in the firms are a key source of Intellectual Capital and Technological Capability as factor of getting competitive sustainable advantages (Conner and Prahalad, 1996; Drucker, 2001; Grant, 1996; Hayek, 1945; Kogut and Zander, 1996; Spender, 1996; Teece *et al.*, 1997). This paper researches the social processes of knowledge on innovative firms proposing that when the members of these firms create and exploit their firm's Technological Capabilities, using social processes of knowledge, at

the same time, they are constructing and developing the firm's Technological Capital, which lead them to get higher incomes (Acosta-Prado and Longo-Somoza, 2013; Acosta-Prado, Bueno & Longo-Somoza, 2014).

In the current economy, knowledge has become a key factor for firms. The competitive organizational environment changes rapidly and transforms knowledge into a critical asset for the adaption process, which firms shouldn't avoid identifying and managing (Bueno, Salmador and Longo-Somoza, 2014; Conner and Prahalad 1996; Grant 1996; Spender 1996). Also, Knowledge is a key ingredient of technology because it plays a crucial role in those processes of creation of technological basis value (Nelson, 1991; Nonaka and Takeuchi, 1995; Prahalad and Hamel, 1990; Sánchez and Mahoney, 1996). Therefore, stimulating and managing knowledge processes is of high importance for firms, and even for countries that want to find the way back to the economic growth in the actual crisis context (Krugman, 2012; Pikkety, 2013; Stiglitz, 2010), because the result is innovation and competitiveness (European Commission, 2003; Hill and Jones, 2010; Schumpeter, 1939).

Several are the strategic approaches of the firms that framework, theoretically and empirically, the research of knowledge processes and Technological Capabilities as critical factors for business success such as 'Resource-Based View of the firm' (Wernerfelt, 1984; Barney, 1991; Grant, 1991), 'Dynamics Capabilities' (Eisenhardt and Martin, 2000; McGrath *et al.*, 1995; Teece, 2009; Teece and Pisano, 1994; Teece *et al.*, 1997) and 'Knowledge-Based Theory' (Grant, 1996; Kogut and Zander, 1992; Nonaka, 1994; Nonaka and Takeuchi, 1995; Spender, 1996; Spender and Grant, 1996; Zander and Kogut, 1995). These lenses, together with Industrial Economy (Porter, 1980), show we must look for those factors that better explain the end results of the firms at the very heart of the organizations. Consequently, we made our analysis looking for these factors from two points of view: 1) on the analysis of the characteristics of the different resources that are considered a source of competitive advantages (Amit and Schoemaker, 1993; Barney, 1991; Grant, 1991; Hall, 1992; Peteraf, 1993; Wernerfelt, 1984); 2) on the analysis of the processes and organizational routines that make

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possible to accumulate and exploit the new resources and relevant Technological Capability needed to face all the menaces and opportunities from a dynamic environment (Acosta-Prado et al., 2013; Cool et al., 2002; Grant, 2002;; Teece et al., 1997). From these point of views, the firm is an entity of learning, which sustained success depends on its capability for speeding up and effectively renew its knowledge stock (Nelson and Winter, 1982).

The empirical case study analysis was conducted in 35 new technology-based firms (Butchart, 1987; European Commission in 2003; Sherman and Burrell, 1988) that participated in a research titled "Intellectual Capital Reports on New-Technology-Based Firms: A Strategic diagnostics on intangible assets" funded by the '*Instituto Madrileño de Desarrollo*' (IMADE) and conducted by the *Universidad Autónoma de Madrid*, Spain, since 2009. The sample were composed by firms created at the Madrid Science Park and the Leganés Science Park in Madrid, Spain. They were small and micro firms (European Commission, 2003) in a process of development. We choose these firms because of their recent foundation and because they asked for technical assistance in order to understand "how to innovate". Moreover, they also asked for help to develop successful ways of work in their critical first years, therefore, they collaborated intensely in the research. In addition, these firms were knowledge-intensive, based on the exploitation of an invention or technological innovation, and employed a high proportion of qualified employees, therefore, they play a relevant role as innovative organizations that create and exploit Technological Capabilities. So, they were suitable in order to study the knowledge processes and Technological Capabilities developed by knowledge-intensive firms.

The paper contribution is both theoretical and practical. On the one hand, we propose a theoretical relationship between Technological Capabilities and Intellectual Capital, specifically the Technological Capital. Also, we propose a conceptual definition and classification of Technological Capability, and moreover, we treat two relevant elements that have rarely been investigated together before in organizational literature such as Technological Capabilities and Intellectual Capital. Despite all the multiple references in literature about the specific qualities of the strategic resources or about the processes needed for the efficient development of the Technological Capabilities (Kristandl and Bontis, 2008), there is no a consensus. With our analysis we try to move forward in the study of these subjects and, specifically, analyze the processes through which the different organizations can improve the management and renewal of their Technological Capability (Acosta-Prado, Bueno & Longo-Somoza, 2014). On the other hand, the contribution is also practical because the findings of the empirical analysis

can help innovation firms' stakeholders to understand the social processes of creating and exploiting knowledge, in firms where knowledge is the critical source of Technological Capability and Technological Capital. Therefore, the findings will help to make decisions accordingly in order to get sustainable competitive advantages and, so, success and higher incomes in a quickly changeable environment.

As we mentioned, this paper researches the social processes of knowledge of operation and exploitation of Technological Capabilities on innovative firms that also create and exploit their Technological Capital, which is an element of their Intellectual Capital (Acosta-Prado and Longo-Somoza, 2013; Bueno et al., 2010a; Bueno et al., 2010b; Bueno, Salmador and Longo-Somoza, 2014). To get this goal we begin with the 'Theoretical Background' section, where, first of all, we characterize, classify and propose a definition of the Technological Capabilities, then, we disclose a conceptual analysis of the Intellectual Capital focusing on Technological Capital and its measurement in the Intellectual Capital Model, a model of identification and measurement of Intellectual Capital (Bueno and CIC-IADE, 2003, 2012), and latter, we propose a theoretical relationship between Technological Capital and Technological Capability through the social processes of knowledge, which create and develop these two elements. Following, the second section 'Empirical Research and Methods' describes the research issue, research context, case study methodology, the sources of data collection and the data analysis procedure. Later the findings are presented. Then, we discuss the conclusions and implications of the research. Finally, the limitations and future research directions are shown.

II. THEORETICAL BACKGROUND

a) Technological Capability

In the eighties decade of the last century, the traditional notion about how to achieve a competitive advantage was initially questioned. Until that moment it was understood that a firm could corner an appealing market by following three generic strategies as leadership in costs, differentiation and segmentation, which would give it a competitive advantage (Porter, 1980). However, then it was reintroduced the strategic approach based on the existence of distinctive competences (Selznick, 1957; Penrose, 1959; Ansoff, 1965), it came up the perspective of a firm based on the resources and capabilities over which competitive advantage can be built (Wernerfelt, 1984; Barney, 1991; Grant, 1991; Amit and Schoemaker, 1993). This approach implies that a firm must try to "know itself", through a deep understanding of its own strategic resources, in order to be able to formulate a strategy for exploiting them and also developing those resources needed for the future.

The approach on dynamic capabilities has to be added to the perspective of the firm based on the resources and capabilities. The dynamic capabilities approach assumes the dynamic character of the environment and the need to adapt to it through the permanent development of new resources and Technological Capabilities (Trece et al., 1997; Eisenhardt and Martín, 2000). In view of turbulent environments, with high doses of uncertainty and complexity, global competition, shortening of the products' life cycle and sudden changes on the likes and needs of the consumers, the firm has indeed problems to decide which needs want to satisfy. However this doesn't mean the firm cannot ask itself – alternatively- which of those needs can be satisfied. In this case, external orientation cannot be the only foundation for business strategy, but also an internal analysis of the available resources and capabilities in order to set up a strategy. This dynamic conception of the theory of resources and capabilities attaches great importance to innovation in business. Within this approach, Technological Capabilities remain one of the most effective instruments in neutralizing the threats and exploiting opportunities offered by the environment, as shown by numerous empirical works (DeCarolis and Deeds, 1999; Balconi, 2002; Figueiredo, 2002; Zahra and Nielsen, 2002; De Carolis, 2003; Nicholls-Nixon and Woo, 2003; Douglas and Ryman, 2003; García and Navas, 2007; Martín-Rojas et al., 2011; Trillo-Holgado, and Fernández-Esquinas, 2013; Ruiz-Jiménez and Fuentes-Fuentes, 2013).

Following the conceptual distinction between resource and capability (Grant, 1991), Technological Capability is defined as any general power of the firm, knowledge-intensive, to jointly mobilize different scientific resources and individual technicians, which allows the development of products and/or innovative and successful production processes, serving the implementation of competitive strategies that create value in view of certain environmental conditions (García and Navas, 2007). This definition suggests that the Technological Capability means the ability to develop and refine the routines that facilitate combining existing knowledge and to disseminate new knowledge gained through the organization and incorporate it into new products, services and/or production processes (Nonaka and Takeuchi, 1995; Grant, 1996, Winter, 2003).

We propose the following definition of Technological Capability, basing our proposal on the above considerations: A Technological Capability involves all of the generic powers of a knowledge-intensive firm to mobilize individual technoscience resources that successfully foster improvement or creation of new products and innovative production processes. The objective is the implementation of competitive strategies that create value under certain

environmental conditions (Acosta, 2009; 2010; Acosta-Prado and Longo-Somoza, 2013).

From the general definition of Technological Capability, as mentioned above, we also provide a Technological Capability classification because it does not always affect in the same way the innovative processes. Therefore, we propose a classification of Technological Capabilities that goes beyond the scope of what is conceptual in terms of academic and managerial implications. Among other proposals in the literature, from the input of March (1991) and Levinthal and March (1993), we have chosen to classify Technological Capabilities based on the nature of knowledge flows, distinguishing between operating and exploring, according to the degree of novelty of the innovation developed, the risk assumed in such processes and the possible and more or less immediate application in the markets for these technological advances (García and Navas, 2007).

More specifically, Levinthal and March (1993) define Technological Capabilities as a strategic exploration of knowledge-intensive systems responsible for the collection of radical innovations, which become technological designs with a dominant position for a certain period of time. On the other side, the Technological Capabilities of strategic operation are responsible for obtaining successive incremental innovations that improve some of its attributes, until there occurs a shift towards a new technological regime. Exploration involves the search for knowledge of facts that can be known and the innovation, novelty seeking and risk taking, and performing all those activities geared towards the discovery of new opportunities. For its part, operation refers to the use and development of facts already known and also in involves the upgrading of the available technology, the "learning by doing", the improvement in the division of labor and all the activities associated with the pursuit of efficiency.

Although these two activities, exploration and operation, are essential for organizations, it is also true they compete for scarce resources. Therefore, certain practices associated with the exploration and operation of knowledge can sometimes be incompatible. As a result, organizations must make explicit and implicit choices between both options (March 1991). Avoiding areas of conflict will require a compromise solution or incorporating a combination of both, that might even be used simultaneously in different parts of the organization. For this reason, maintaining a balance between exploration and operation is a key factor for survival and competitive success (Levinthal and March, 1993; Zack, 1999; Grant, 2002; Ichijo, 2002).

Summarizing briefly what we have looked at until now, the exploration and operation of technological knowledge are the result of an exchange process between the environment incentives, the existing knowledge in the organization and the actions of its

members, and such knowledge and actions are *input* and *output* in the conversion flows and change in the knowledge stocks. These considerations lead us to a new perspective on Technological Capabilities and to understand the dynamic potential of creation, assimilation, dissemination and use of knowledge by means of flows that make possible the training and assessment of stocks of knowledge, training the organization and the people, flows which are made up of to act in changing environments (March, 1991). Undoubtedly, the stocks of knowledge affect the perception and understanding of reality, but if reality changes then it will be necessary to renew the firm's knowledge base to suit the new conditions of the environment, through flows of knowledge. Thus, the knowledge flows incorporating both cognitive and behavior changes and providing the means to understand how the body of knowledge in the organization evolves through time, increasing its range and adaptability (Von Krogh and Vicari, 1993; Carmeli, and Azeroual, 2009; Ruiz-Jiménez and Fuentes-Fuentes, 2013).

The proposed classification made of Technological Capabilities of exploration and operation is important due to that the uneven nature of the knowledge which flows in each case will require different decisions, regarding the disposition and use of resources and capabilities of the business and market opportunities. For this reason, the innovative firms develop Technological Capabilities of exploration and operation through the mobilization of resources technoscience for the improvement or creation of new products and successful innovative production processes. The processes involved in this development are knowledge processes that make possible to accumulate and exploit the new resources and relevant Technological Capability needed to face all the menaces and opportunities from a dynamic environment (Teece et al., 1997; Cool et al., 2002; Grant, 2002; Bueno et al., 2010a; Acosta-Prado and Longo-Somoza, 2013). The Technological Capabilities developed can be classified as follows (Acosta, 2010; Bueno et al., 2010a; Acosta-Prado et al., 2013)

Particularly, we suggest that the knowledge processes that make possible the accumulation and exploitation of the new resources and relevant Technological Capability are: Investments to acquire knowledge used to develop very specific activities; Use of knowledge derived from database, patents, etc, used to develop technologically improved or new products and services and which requires the utilization of different technologies; Easy storage of technological knowledge in soft, hardware or documents; Acquisition of knowledge through the hiring of qualified staff, through the relations with other firms and which involves a high degree of novelty and it is easily codified.

b) *The Technological Capital in the Intellectus Model*

It was Marshall who introduced the study of knowledge as a source of wealth creation in Economy in the 19th century (Bueno, 2002). He stated 'Knowledge is our most powerful engine of production' (Marshall, 1890). Along the last century the study of knowledge as firms' critical factor was developed by researchers such as Knight (1921), Hayek (1945), Drucker (1965) and Machlup (1980). People working in organizations commit themselves and contribute with their knowledge. Thus, firms acquire this knowledge which can become technology if it is developed and transmitted. Therefore, individual knowledge can be transformed into social or collective knowledge and shared by the members of an organization when transferred through oral or written language, that is, through knowledge processes (Acosta-Prado and Longo-Somoza, 2013; Argyris and Schön, 1978; Quinn, 1992; Von Krogh and Roos, 1995; Spender, 1996; De Geus, 1997; Cook and Brown, 1999; Bueno, 2005; Bueno et al., 2010b).

In organizations knowledge circulates in many ways. It circulates through articles or written procedures, and also through unwritten artefacts such as stories, specialized language, and common wisdom about cause-effect relationships. People observe and discuss, for example informal work routines, and, doing so, they exchange their experience, make sense of the information and also share and use their knowledge. Levering and managing knowledge involves getting people together in order they share insights they do not know they have. Through this social process of interaction and communication, members creates and expands knowledge (Nonaka, 1994; Nonaka and Takeuchi, 1995; Polanyi, 1969). In innovative firms, these social processes of knowledge construct and develop their Intellectual Capital or intangible assets (Acosta-Prado, Bueno and Longo-Somoza, 2014; Acosta-Prado and Longo-Somoza, 2013, Bueno et al, 2010a; Bueno et al., 2010b).

In spite of the relevance of knowledge processes in firms, it wasn't until the last decade of the 20th century when a great interest in knowledge management emerged as a way of leveraging the strategically relevant knowledge for the organization (Teece, 2000). Currently, traditional tangible assets are still important for firms but knowledge has become a key asset to manage in order to gain wealth creation and sustainable competitive advantages in a quick changeable environment (Boulton *et al.*, 2000; Lev, 2001; Low, 2000). These intangible assets based on knowledge have been recognized by the market and have generated the concept of Intellectual Capital (IC), which was proposed in 1990s (Edvinsson and Malone, 1997; Roos *et al.*, 1997; Stewart, 1997; Sveiby, 1997). IC is generally defined as the intellectual material that can be put to use to create wealth. It includes organization's processes, technologies, patents, employees' skills and

information about customers, suppliers and stakeholders (Stewart, 1997). Internationally they are accepted three basic dimensions, they are Human Capital, Relational Capital and Structural Capital (Bueno, Salmador and Longo-Somoza, 2014).

Human Capital is concerned with the accumulated value or wealth generated by the values, knowledge and abilities of people (Human Intelligence) and it represents the stock of knowledge within an organization rather than in the minds of individual employees (Bontis *et al.*, 2002).

Structural Capital expresses the accumulated value or wealth generated by the value of the existing knowledge, which is property of the organization that generates its knowledge base. This knowledge is the combination of shared values, culture, routines, protocols, procedures, systems, technological developments and intellectual property of an organization which make up the collective know how and which remain in the entity whether people leave (Organizational Intelligence). The Structural Capital is divided in Organizational Capital and Technological Capital. The Organizational Capital is a combination of intangibles that structure and develop the organizational activity. That is, The Technological Capital is a combination of intangibles directly linked to the development of activities and functions of the technical system of the organization's operations which is responsible for obtaining products, developing efficient production processes and advancing the knowledge base necessary for future innovations in products and processes.

Relational Capital expresses the accumulated value or wealth generated by the value of the knowledge which comes to the organization through the relationships and actions shared with external or social agents (Social and Competitive Intelligence) and it refers to customers, social capital, and stakeholders (Bukh, 2003; Johanson *et al.*, 2001; Stewart, 1997; Ordoñez, 2003). The Relational Capital it is segmented in Business Capital and Social Capital. The former is directly related to the agents linked to the business process, and the latter is connected with the remaining agents (Bueno, 2002; Coleman, 1988; McElroy, 2001; Nahapiet and Goshal, 1998).

The Intellectus Model (Bueno and CIC-IADE, 2003, 2012) identifies and measures Intellectual Capital. It was designed in 2003 and revised in 2012 for the measurement and management of the intangible assets which compose the concept of Intellectual Capital. It was the result of the participation and consensus of public and private agents in the 'Knowledge and Innovation Intellectus Forum' as a reflection and transfer platform conducted by IADE, the University Research Institute in Business Administration of the *Universidad Autónoma de Madrid*. It shapes a tree which clarifies the interrelations between the firm's intangible assets through the identification of four levels of aggregation: components, elements, variables and indicators (Figure 1). The ability of the Intellectus Model to assess and measure Intellectual Capital resides in its capacity to adapt to the needs of each firm, because of it is systemic, open, dynamic, flexible, adaptive and innovative.

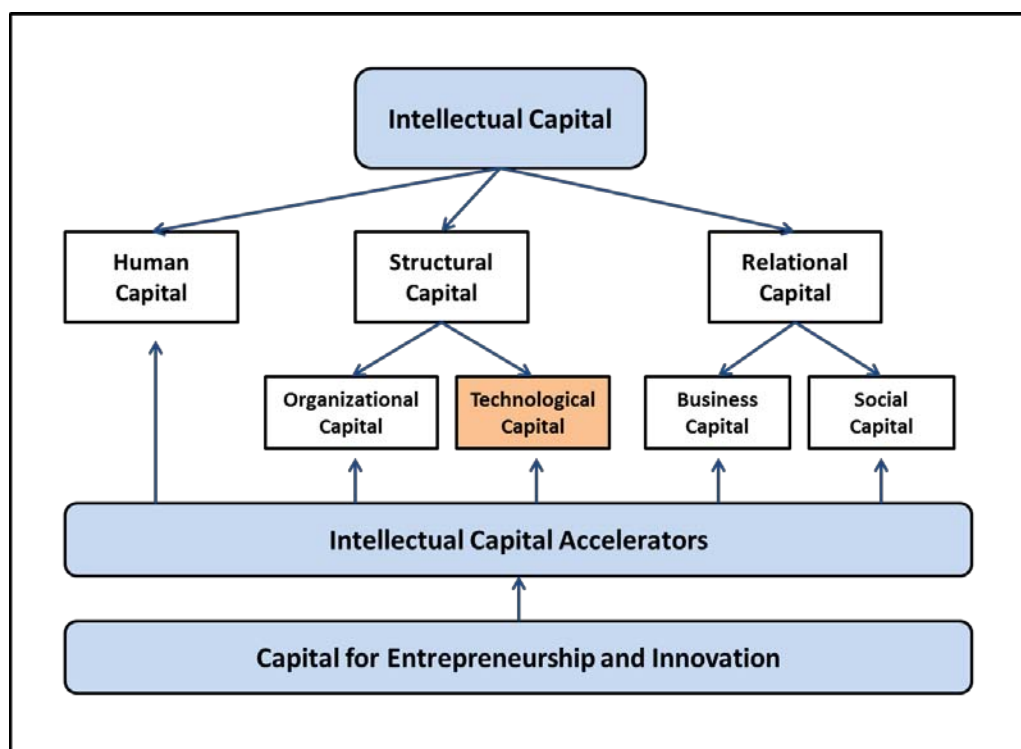


Figure 1 : Intellectus Model

Source: Bueno and CIC-IADE (2012)

To the purposes of this paper we have to focus on the Technological Capital. The Intellectus Model discloses the groups or elements of intangible assets in order to measure and manage the social processes of knowledge that compose the Technological Capital: Effort in Research and Development and Innovation (R&D&I); Technology Infrastructure; Intellectual and Industrial Property; and Technological Surveillance (Bueno and CIC-IADE, 2012).

These elements gather intangible assets with homogenous characteristics. Thus: Effort in R & D & I refers to the efforts made in technological innovation processes; Technological Infrastructure is a Combination of knowledge, methods and techniques which the Organization incorporates into its processes so that they are more efficient and effective. They are accumulated through external sources; Intellectual and Industrial Property represents the legally protected knowledge which grants the firm which created it the exclusive right to its exploitation in a predetermined time and area; and Technological Surveillance is a set of tools and techniques to capture technological information outside the organization that expresses the ability to analyze it and convert into knowledge for decision-making to facilitate anticipate change and sustain competitive advantage. It is also known as competitive intelligence or organizational intelligence processes to cope with change, turbulence and uncertainty of the environment.

c) *Relationship between Technological Capability and Technological Capital*

The elements that relate the Technological Capability and the Technological Capital are the social processes of knowledge developed by an organization. They include a broad range of firm's activities, which help to generate new knowledge or improve the existing one (Acosta-Prado and Longo-Somoza, 2013; Bueno et al., 2010a; Bueno et al., 2010b). This knowledge is applied to the procurement of new goods and services and new forms of production (López et al., 2004). As noted before, this is determined by the relationship between organizational characteristics and their outcomes and by the identification and sustainability of the organizational change, as well as the adaptation of the conditions, context and resources that make more efficient and faster the production of innovations facilitating the resolution of problems, fostering personal engagement and approaching these actions towards the creation of competitive advantage.

There are several the researchers who have related Technological Capability and Technological Capital through the knowledge processes generated by a firm. On the one hand Rogers (1996) relates the development of Technological Capability and Technological Capital, through the concept of *innovation*

of knowledge, understanding that innovation is an informational process in which knowledge is acquired, processed and transferred (Escorsa and Maspons, 2001). Thus, the organization must recognize and seize new opportunities through the creation and use of the knowledge needed to develop Technological Capability and split the existing ones (Hamel and Prahalad, 1993; Woolley, 2010).

On the other hand, Aragon-Correa et al. (2005) suggest this relationship comes after the use of a specific technology, as a means to introduce a change in the firm, and they call this link innovation. This approach highlights the importance of linking technology to the organization both through its implementation, design and development, as well as through the underlying philosophy or culture of innovation (Orengo et al., 2001). Therefore, technological innovation is a process through which the firm may involve deeper changes in scientific and technological advances (Benavides, 1998), incorporated into new products and/or production processes carried out in order to adapt to the environment and create sustainable competitive advantages (Lopez et al., 2004).

Moreover, understanding technological innovation has led some authors to describe the phenomenon as a technological change, referred to the provision and use of technologies and the allocation of areas such as dynamism, specificity, interaction and social aspects to human action in the organizational context (Friedman, 1994). We would like to note that the coexistence of the terms used in the present, technological innovation and technological change, does not mean confrontation between them. Thus, West and Farr (1990) suggest that certainly any kind of innovation, in terms of organization, is a change, although not every change is innovation. Thus, technological innovation is a dimension of organizational change that reflects the intent of obtains a benefit, based on the development and operation of strategic technological intangibles which determine the innovating outcome (Cohen and Walsh, 2000; Cohen et al., 2002; Woolley, 2010; Ruiz-Jiménez and Fuentes-Fuentes, 2013; Bueno, 2013).

For all the reasons stated, it can be said that the development of Technological Capability is the result of some processes of knowledge. Some other authors can also be named who study this aspect of the Technological Capabilities. Cohen and Levinthal (1990) propose they are the result of a lengthy process and of the accumulation of knowledge within the firm, which may be affected by facilitating factors or inhibitors of these capabilities (Cohen and Levinthal, 1990), process which involves both the effects of appropriation and obtaining knowledge (Cohen and Levinthal, 1990; Nieto and Quevedo, 2005) and the protection of competitive results (Cassiman and Veugelers, 2002). Therefore, it is

necessary to develop a strategy in order to promote the proper exploration and operation of the Technological Capability that lead to new and innovative forms of competitive advantage, given a specific temporal dependence and a market position (Leonard-Barton, 1993).

The social aspect of Technological Capability and Technological Capital is also studied in the organizational literature. For example, Dawson (2000) states that development of Technological Capability of a firm principally depend of four aspects: the individual technology, organizational technology, behaviors and skills of individuals and organizational skills and behaviors. In this particular, Meso and Smith (2000) propose two points of view -technical and sociotechnical- in order to understand both the emergence of strategic assets and the knowledge transfer between employees and the firm and vice versa. The technical perspective is associated with the use of information technologies to support knowledge creation in the firm (e.g., databases, documentation systems, search and data mining systems, teams' decisions support systems, corporate portals, etc.). The sociotechnical perspective recognizes that the interdependent and complementary nature of knowledge should enable the firm assess the strategic relevance of its knowledge assets, and be able to establish the strategy that, in its business environment, leads to the formation of the most suitable knowledge base for achieving sustainable competitive advantages. Finally, they conclude that firms that only operate the tangible aspects of knowledge do not have a competitive advantage.

In addition, De Carolis and Deeds (1999) examine the relationship between knowledge and performance in the biotechnology industry. The accumulation of knowledge is the result not only of the internal developments but also the assimilation of external knowledge. While making operational the knowledge flow, they took into account three variables: location, alliances and R & D spending. Regarding inventories of organizational flows, they took the following variables: products in stage of development, firms' patents and researches. They concluded that the management of stocks and flows of knowledge seems to be something special to succeed. In any case, additional empirical investigations are needed to improve understanding between knowledge-intensive Technological Capabilities and business performance.

Another group authors such as Acosta-Prado and Longo-Somoza (2013), Acosta-Prado, Bueno and Longo-Somoza (2014), Bueno et al.(2010a),Bueno et al.(2010b) and Bueno (2013) state that there is a relation between the social processes of interaction developed by NTBFs to create and develop the Intellectual Capital and the ones focus on creating and developing the Technological Capabilities, and that they are processes

of knowledge. Intensive knowledge firms hire a high proportion of qualified employees and researchers who think the best way to operate and exploit an invention and technological innovation is to develop actions of cooperating and working in group, and exchanging and sharing knowledge between all members through conversations. To facilitate these processes, they promote informal relations and design formal channels of communication, besides they construct and develop their Intellectual Capital and Technological Capability at the same time.

In conclusion we have made a literature review taking the strategic approaches of the firm as Resource-Based View (Wernerfelt, 1984; Barney, 1991; Grant, 1991) Dynamics Capabilities (Teece and Pisano, 1994; Teece et al., 1997; Eisenhardt and Martin, 2000; Teece, 2009) and knowledge-Based Theory (Kogut and Zander, 1992; Nonaka, 1994; Nonaka and Takeuchi, 1995; Zander and Kogut, 1995; Grant, 1996; Spender, 1996; Spender and Grant, 1996). This literature review leads us to propose that there is a relationship between the Technological Capability and the Technological Capital in the innovative firms. The reason is that both of them are created and developed by the same kind of social processes of knowledge. Moreover these social processes of knowledge involve the accumulation of knowledge within the firm, the assimilation of external knowledge, the individual technology, the organizational technology, the behaviors and skills of individuals and organizational skills and behaviors.

III. EMPIRICAL RESEARCH AND METHODS

a) *Research issue*

The theoretical background suggest the social processes of knowledge developed by innovative firms are core factors of Technological Capability and Technological Capital, they are the same processes and they are also a critical key to get competitive sustainable advantages. Therefore, grounded in this theoretical relationship, we empirically investigate what these social processes are and what Technological Capabilities and Technological Capital are constructed and developed by them in innovative firms. This relationship has been understudied in the organizational literature, however to innovative firms it is interesting to know in order to help organizations to understand "How they innovate" and, therefore, define their strategy and set the base of their success.

b) *Research context*

The empirical analysis was conducted in 35 New-Technology-Based Firms (NTBFs) of the Madrid Scientific Park (PCM) and the Leganés Science Park (LEGATEC), in the Community of Madrid, Spain. As NTBFs, they focused on sectors which had higher than average expenditures on R&D as a proportion of sales or they employed proportionately more qualified

scientists and engineers than other sectors; also, they were independently owned business and based on the exploitation of an invention or technological innovation which implies substantial technological risks (Butchart, 1987; Little, 1977; Shearman and Burrell, 1988). Moreover, they were micro a small firms. A small firm is defined as an enterprise which employs fewer than 50 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 10 million. A micro firm is defined as an enterprise which employs less than 10 people and whose annual turnover and/or annual balance sheet total does not exceed EUR 2 million (European Commission, 2003). For all of these reasons, the firms of the sample can be qualified as innovative firms and suitable to test the research issue. Although the sample was not random, it reflected a representative selection of NTBF's established at the Science Madrid Park and Leganés Science Park.

Space prevents us from providing "thick descriptions" of each case (McClintock et al., 1979),

however, Table 1 makes a brief description of the firms at the time of our analysis. The technical file of the empirical study showing the period and average durations of the interviews, the legal entity of the firms, their activity sector, the number of employees and informants or information source. The table discloses that the firms that took part in the study were micro and small firms as they have from 4 to 19 employees. Also, they were innovative firms established between 2000 and 2007 as Limited Companies and belong to activity sectors based on the exploitation of an invention or technological innovation. These sectors are: Information, Technology and Communications, Biotechnology and Agro-food and Environment and Renewable Energies. They employed qualified people with a PhD, Master or Bachelor Degree. The data-collection process took place in the period 2008-2009.

Table 1 : Technical File

Country-Region	Spain-Madrid
Activity sector	Information, Technology and Communications, Biotechnology, Agro-food, Environment, Renewable
	Energies
Sampling unit	NTBFs
Sample	35 NBTFs of the Madrid Science Park (PCM) and of the Leganés Science Park (LEGATE C)
Date of establishment	2000-2007
Employees	4-19
Informationsource	Promoter-Founder and/or CEO and one or two employees
Legal entity	LimitedCompany
Averagelength of interview	60 minutes
Date of collection	2008-2009

Source: Own elaboration

The criteria for selecting these firms were the following: 1) they had been recently founded and they asked for technical assistance in order to understand "how to innovate" as well as to develop successful ways of work in their critical first years, for that, they collaborated intensely in the research; 2) They carried out the identification and measurement of their Intellectual Capital using the Intellectus Model; 3) They were knowledge-intensive, based on the exploitation of an invention or technological innovation, employed a high proportion of qualified employees and skilled in highly specialized fields; 4) They belonged to different industries, and this allowed us to treat this element as a ceteris paribus variable and to focus on Technological Capabilities and Technological Capital shared by them. So, as mentioned, these firms were suitable to study the social processes of knowledge that constructed and

developed Technological Capabilities and Technological Capital.

c) Case study methodology

The empirical study was conducted using a multiple-case study methodology suitable for answering "how" and "why" questions (Yin, 2014) and that also enables to use "controlled opportunism" to respond flexibly to new discoveries made while collecting new data (Eisenhardt, 1989). The comparison of case studies within the same context (NBTFs of the Madrid Science Park and of the Leganés Science Park) enables the "analytic generalization" through the replication of results, either literally (when similar responses emerged) or theoretically (when contrary results emerge for predictable reasons) (Yin, 2014). Thus we ensure that the evidence in one well-described setting is not wholly idiosyncratic (Miles and Huberman, 1984). Furthermore,

the case study methodology provided a real-time study of this paper research issue in the natural field setting by investigating the 35 new technology-based firms of the sample. In addition, with this methodology we ensured that the data collection and the analysis met the tests of construct validity, reliability, and internal and external validity by carefully considering Yin's tactics (2014).

Construct validity was enhanced by establishing a chain of evidence when we concluded the interviews and by using the multiple sources of evidence such as interviews, observations and secondary data sources. The underlying rationale was "triangulation", which it is possible by using multiple data sources providing stronger substantiation of constructs and propositions (Webb et al., 1996). Reliability was promoted by: (a) Using a case-study protocol in which all firms and all informants were subjects to the same entry and exit procedures and interview questions; (b) using a pilot study was carried out to refine our data-collection plan with respect to both the content of the data and the procedures followed; (c) by creating similarly organized case data bases for each firm we visited. External validity was assured by the multiple-case research design itself, whereby all cases were NTBFs of Madrid Science Park and Leganés Science Park. Finally, we addressed internal validity by the pattern-matching data-analysis method described in "Data Analysis Procedure" section.

d) Interviews

The primary source of initial data collection came from semi-structured interviews with fifty two informants which lasted sixty minutes on average per case. We needed to obtain various points of view and to avoid slants so these interviews were conducted with several informants in each firm: the Promoter-Founder and/or CEO and one or two employees, all of them qualified people with a PhD, Master or Bachelor Degree. In order to obtain data about the social processes of knowledge, the Technological Capability and the Technological Capital, we divided the interviews in two stages. In the first stage, we asked the respondents global aspects of the firm such as: to describe his/her job in the firm, open questions about the history of the firm, activity sector, structure, core characteristics, strengths, customers, relations with the Scientific Park and other firms. In the second stage, we focused on areas such as the feeling of being a community, ways of share, storage and protect knowledge, climate between members, business philosophy, share values, the communications ways between them, departments or formal functions, infrastructures and financial support.

e) Observations and Secondary Sources

We used secondary sources and data to supplement the data obtained from the interviews and to collect background information about the 35 NTBFs.

The secondary sources were annual reports, internal documents provided by the interviewees, meeting agendas, minutes, internal newsletters and intranets, industry reports, websites, and articles in magazines and newspapers about the situation and evolution of the industry and of the 35 NTBFs in particular. Additionally, we reviewed the firms' reports about the identification and measurement of their Technological Capital using the Intellectus Model. We also kept a record of the impressions and observations we made when we participated in firms' activities such as coffee breaks and lunches. Whenever possible, we attended meetings as passive note-takers. These observations provided real-time data. The impressions and observations were related with the social processes of knowledge and their results.

f) Data Analysis Procedure

The final explanation of the research issue of this multiple-case research has been the result of: (1) the theoretical propositions initially established about Technological Capital and Technological Capability; (2) an iterative process of comparisons between these propositions and the findings; (3) a continuous revision of the propositions. Specifically, to analyze the collected data we set the general analytic strategy called "relying on theoretical propositions" (Yin, 2014). To follow this strategy first we described the theoretical propositions about the concepts of Technological Capital and Technological Capability in section 'Theoretical Background'. Second, these theoretical propositions will be the guide to analysis the empirical evidence (see 'Findings' section) to answer the research question stated in the 'Research Issue' section. Also, we have followed the explanation-building data-analysis method, which is a special type of pattern-matching method. We have chosen this method to analyze data because it is a relevant procedure for explanatory case studies where casual links are in narrative form (Yin, 2014).

Tables has been used as techniques of data-analysis. They have helped us to put in order the data, to make comparisons between the empirical evidence, and to present the relations between the data and the theoretical propositions (Miles and Huberman, 1984).

IV. FINDINGS

The analysis of the collected data provided a preliminary understanding and description of the social processes of knowledge that construct and develop Technological Capability and Technological Capital in NTBFs. To do it we have identified their entire set of elements of tangible or intangible nature and the social processes of knowledge related with them.

Guided by the Theoretical Background section we started the analysis of the data searching by the employees' interactions that help to generate new

knowledge or improve the existing one. In other words, we looked for the actions of cooperating and working in group, and exchanging and sharing knowledge between all members through conversations. By doing this, we found the relevant social processes of knowledge, which contribute at the same time to the construction of the investigated firms' Technological Capability and

Technological Capital. These processes are disclosed in the first column of Table 2. Also, in the second column we specified the activities involved in the processes, which are associated with science parks and influence in the construction of Technological Capability and Technological Capital.

Table 2: Social Processes of Knowledge in NTBFs which influence their Technological Capability and Technological Capital

Social Processes of Knowledge	Activities involved in the Social Processes of Knowledge
Processes of intrinsic nature of innovative firms	Technological surveillance and adaptation at changing environment
	R&D&I expenses (total sales and total production)
	Specialization of personnel in R&D&I
	Projects in R&D&I
	Purchase of technology
	Infrastructure of production technology
	Infrastructure of information and communication technologies
Processes of external nature of innovative firms	Relevant customer base
	Generation of Cooperation Networks
	Permanent Updating
	Knowledge of competitors
	Relationships with suppliers
	Relationships with public administration
Processes of intrinsic nature of innovative firms associated with science parks	Relationships with institutions and investors
	Learning environment
	Capture and transmission of knowledge
	Creation and development of knowledge
	Strategic Alliances
Processes of external nature of innovative firms associated with science parks	Intellectual and industrial property
	Support for internationalization
	Access to new financial instruments

Source: Own elaboration

The analysis of the data also provided the relevant Technological Capabilities developed by the NTBFs of the sample. These capabilities are:

1. Investments to acquire knowledge used to develop very specific activities.
2. Use of knowledge derived from database, patents, technical reports, etc.
3. Acquisition of knowledge that involves a high degree of novelty.
4. Use of the technology which requires the utilization of a combination of different technologies.

5. Acquisition of knowledge through the hiring of qualified staff.
6. Use of knowledge to develop technologically improved products and services.
7. Use of knowledge to develop technologically new products and services.
8. Easy storage of technological knowledge in soft, hardware or documents.

The data also revealed the Technological Capital of the NTBFs. The analysis showed that the firms

of the sample have a strong Technological Capital to ensure their growth and survival. They refers to a set of intangibles associated with the development of activities and functions of the technical system of the firm, responsible both for the delivery of outputs (goods and services) with a set of specific attributes and the development of efficient production processes and for the progress on the knowledge base needed to develop future innovations in products and services. We

matched the Technological Capital addressing during the interviews with the nomenclature in the Intellectus Model, moreover we classified the Technological Capital in strengths and areas for improvement. The results are showed in Table 3. Data analysis also allow us to ensure that only those NTBFs able to efficiently manage their technological knowledge may alter their resource base and routines based on the strategic requirements of their environment.

Table 3 : Technological Capital in NTBFs

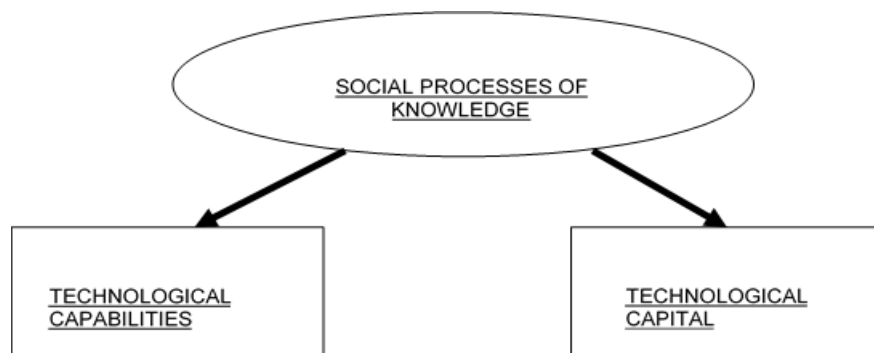
	Nomenclature in the Intellectus Model	Concepts address during the interviews
Strengths	Effort in R&D&I	Guidance to R&D
	Intellectual and industrial property	Differentiation of the offer
	Technological infrastructure	Specialized know-how
	Intellectual and industrial property	Sensibility and development of the intellectual property
Areas for improvement	Technological Surveillance System	Technological surveillance
	Networking of international R&D	Effort in R&D&I
	Advantages of the offer	Intellectual and industrial property

Source: Own elaboration

Summarizing, the data analysis corroborates the research issue, which asserts the social processes of knowledge developed by innovative firms are core factors of Technological Capability and Technological Capital. This processes describes how NTBFs innovate to achieve success. Specifically, when innovative firms develop their Technological Capability through of the mobilization of resources technoscience for the

improvement or creation of new products and innovative production processes successfully, at the same time, they are also constructing the elements of their Technological Capital. The model shows in Figure 2 summarises the findings showing the knowledge process which contribute at the same time to the construction and development of Technological Capability and the Technological Capital.

Figure 2 : Knowledge processes, Technological Capabilities and Technological Capital in NTBFs



Source: Own elaboration

V. CONCLUSIONS AND MANAGERIAL IMPLICATIONS

In this paper we have studied the relationship between the Technological Capability and the

Intellectual Capital in innovation firms. After a review of the literature about this two concepts, we have proposed that the social processes of knowledge developed by innovative firms are core factors of Technological Capability and Technological Capital.

Specifically, we proposed that When the members of innovative firms interact to mobilize knowledge, they create and develop the firm's Technological Capability and, at the same time, the Technological Capital. The organizational literature has already studied how Technological Capital and Technological Capability are key elements in the processes of strategic change and in situations of external context changes. However, past studies have not explored in depth the relationship between Technological Capability and Technological Capital in new organizations.

The model in Figure 2 summarises the findings showing the social process of knowledge that contribute to the construction and development of Technological Capability and the Technological Capital at the same time. The processes involve the accumulation of knowledge within the firm, the assimilation of external knowledge, the individual technology, the organizational technology, the behaviors and skills of individuals and organizational skills and behaviors. The result are Technological Capabilities and Technological Capital which are critical factors for achieving competitive sustainable advantages. From the Resource-Based View strategic approach, the Dynamics Capabilities approach and the Knowledge-Based Theory, we cannot avoid emphasizing the importance of knowledge for firms and countries to find the way back to growth hence the importance of studying its processes and results.

We framed the paper by making a theoretical review of the Technological Capital in the Intellectus Model, as a model of measurement of Intellectual Capital, and by discussing the main approaches in the field of the Technological Capability. We have concluded that the more adequate approach to develop our research was the Intellectual Capital and the Resource-Based View, Dynamics Capabilities and knowledge-Based Theory. To test the research issue, we have selected a case study methodology and we have used as primary data collection instrument semi-structured interviews, and as secondary data collection instruments observation and secondary resources. Thus, we conducted a multiple-case study to analyze the relationship between the construction and development of Technological Capability and Technological Capital in 35 new technology-based firms created at the Madrid Science Park and the Leganés Science Park, which are innovative firms.

The objective of the interviews was understand how the NTBFs construct their Technological Capability to answer the question "How do they innovate?" Doing this we have found (Figure 2): (1) the social processes of knowledge that contribute to the construction and development of the Technological Capability and the Technological Capital at the same time; (2) the Technology Capabilities develop in NTBFs; (3) the variables of the Technological Capital that were also

constructed. These findings allow us to conclude that during the processes of construction of Technological Capability the 35 new technology-based firms of the study also constructed their Technological Capital. Following Intellectus Model, we have identified the elements of Technological Capital and the strengths and areas of improvement in these firms (Table 3): Effort in R & D & I; Technological infrastructure; Intellectual and industrial property; Technological surveillance.

Therefore, in the 35 NTBFs analyzed the data corroborates the research issue, that is, the social processes of knowledge developed by innovative firms are critical factors of Technological Capital and Technological Capability. The NTBFs of the sample were small and micro innovative firms with a high proportion of employees and researchers qualified who develop social processes of knowledge in order to develop the best way to explore and exploit an invention and technological innovation through working in group, exchanging and sharing knowledge between all the members through conversations, infrastructure of information and communication technologies and infrastructure of production technologies.

The contribution of our analysis is both theoretical and practical. On one hand, from a theoretical point of view, we have proposed: (1) a definition of Technological Capability; (2) a classification of Technological Capabilities; (3) and a theoretical relationship between Technological Capabilities and Intellectual Capital, specifically the Technological Capital, through social processes of knowledge. Furthermore, we have treated two outstanding concepts in organizational literature that have hardly been investigated empirically together which are: Technological Capabilities and Intellectual Capital. On the other hand, from a practical point of view, the findings of our empirical analysis will help innovation firms' members, and stakeholders (investors, government, etc.) in general to make suitable strategic and tactic decisions in order to get sustainable competitive advantages and, therefore, success in a quickly changeable environment by managing: (1) the social processes of knowledge which construct and develop Technological Capability and Technological Capital; (2) the specific Technological Capabilities and elements of Technological Capital constructed and developed; (3) and the strengths and areas for improvement in the Technological Capital.

It can be concluded that, the congruence between the Technological Capability and Intellectual Capital development promotes the adaptability of NTBFs to the environment and the absorption of information and generation of useful knowledge by carrying out actions that impact the outcome of the NTBF such as profitability, sales or profit growth and productivity at work. Also, Technological Capabilities

and Technological Capital play an important role because, through its dynamic function, they are responsible for a support activity, and give the firm appropriate resources and routines, needed to create value both directly and indirectly. Directly in primary activities and indirectly, ensuring the quality, reliability, profitability and competitiveness of technological knowledge, and supporting activities whose outcome can serve to improve the knowledge base and the relationship between the firm and its customers, the quality of its products and services, but also the level of employee satisfaction, among others. All of this, through the social processes of acquisition, development and dissemination of knowledge to generate competitive advantage and create value for the firm.

VI. LIMITATIONS AND FUTURE RESEARCH

As every empirical research ours is not free of limitations, which serve as guidelines for future studies in the field of Social Processes of Knowledge, Technological Capability and its relationship with the Intellectual Capital. We want to address them through alternative analysis in future researches.

The research issue was tested using a multiple-case methodology in 35 NTBFs created at the Madrid Science Park and Leganés Science Park so the findings cannot be generalized. However, these findings can serve as a starting point for future research to make generalizations in the context of NTBFs and in the context of other sciences parks and even in other kind of new organizations different from NTBFs. Moreover, we have focused our efforts in studying the relationship between the construction of Technological Capability and the Technological Capital of 35 NTBFs. However, we have not analyzed the relation of these concepts to the success of these firms.

Finally, in the 'Theoretical Background' section we have made a literature review to support our proposal that the social processes of knowledge developed by innovative firms are critical factors of Technological Capital and Technological Capability. Accordingly, we have applied a case study methodology to identify these processes and identify the Technological Capital and the Technological Capabilities they develop. However, it would be very interesting to study these processes characteristics, their potential to strengthen the resources base and capabilities of the firms and how, when they are accumulated and levered together, lead to the emergence of Technological Capabilities and Technological Capital.

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