



HOW FIRM APPROPRIATELY APPLY NEW EXTERNAL KNOWLEDGE: THE WATERFALL MODEL OF ABSORPTIVE CAPACITY AND INNOVATION

Como aplicar adequadamente o novo conhecimento externo: o modelo cachoeira de capacidade absorviva e inovação

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ABSTRACT

This article was an attempt to brief a new model of absorptive capacity and develop the concept of absorptive capacity which is a critical factor in applying, accumulating and linking new external knowledge to innovation. Through a comprehensive review of literature on absorptive capacity, authors ended up with the idea that the stream of new external knowledge in the waterfall model continually fosters all abilities of absorptive capacity. In addition, following knowledge spillover in each stage, abilities perform their activities. Knowledge accumulation is also another capability, which in this process, plays the role of linking absorptive capacity and innovation.

Key-words: Absorptive Capacity; Knowledge Accumulation; Innovation; Organizational Antecedents.

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COMO APLICAR ADEQUADAMENTE O NOVO CONHECIMENTO EXTERNO: O MODELO CACHOEIRA DE CAPACIDADE ABSORVIVA E INOVAÇÃO

How to properly apply new external knowledge: the waterfall model of absorptive capacity and innovation

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RESUMO

Este artigo foi uma tentativa de apresentar um novo modelo de capacidade de absorção e desenvolver o conceito de capacidade de absorção que é um fator crítico na aplicação, acumulação e vinculação de novos conhecimentos externos à inovação. Por meio de uma ampla revisão da literatura sobre capacidade absorviva, os autores chegaram à ideia de que o fluxo de novos conhecimentos externos no modelo em cascata promove continuamente todas as habilidades de capacidade absorviva. Além disso, após o transbordamento de conhecimento em cada estágio, as habilidades realizam suas atividades. A acumulação de conhecimento também é outra capacidade que, nesse processo, desempenha o papel de vincular capacidade de absorção e inovação.

Palavras-chave: Capacidade de Absorção; Acúmulo de Conhecimento; Inovação; Antecedentes Organizacionais.

INTRODUCTION

Many scholars have argued that knowledge, intertwined with innovation, is a critical factor for commercial ends (Cohen and Levinthal 1990; Davenport and Prusak, 1998; Jansen et al., 2007; Murovec and Prodan, 2009; Zhixiong and Yuanjian, 2010). Earlier, in 1985, Drucker proposed that knowledge would replace equipment, capital, materials, and labor to become the key element in production. Two decades later, in 1993, he maintained that competitive advantage in the future will be determined by knowledge resources, or what is known as knowledge workers. Barney (1991), defined information and knowledge as firm resources. Nonaka (1994), also defined information as flow of messages, while knowledge is created and organized by the very flow of information, anchored on the commitment and beliefs of its holder. In fact, firms should deal with new external knowledge to apply it to innovation which is critical to firms to survive and adapt in turbulent environments (Cohen and Levinthal, 1990; Schmidt, 2005; Xiu-mei et al., 2007; Wang and Chen, 2009; Escribano et al., 2009; Fabrizio, 2009; Zhixiong and Yuanjian, 2010). Cohen and Levinthal in 1990 refer to this capability as Absorptive Capacity (AC) which is the internal knowledge base of a firm with two individual and organizational perspectives. According to Nonaka (1994), a firm's success is guaranteed, when in dynamic and turbulent environments, it can process and generate new external knowledge. Many researchers claimed that innovation relies on a base of common knowledge (Liao et al., 2010). Similarly, Jansen et al. (2005) pinpoint that firms, to survive in turbulent environments, should rely on new external knowledge as a source of competitive advantage. Many scholars argued that firms, that manage capability of AC successfully, can have access to innovation (Cohen and Levinthal, 1990; Schmidt, 2005; Xiu-mei et al., 2007; Wang and Chen, 2009; Escribano et al., 2009; Fabrizio, 2009; Zhixiong and Yuanjin, 2010). Innovation has been identified as an important factor in a firm's survival (Jia and Xia, 2008). Escribano, et al. (2009) maintained that enterprises, to rival in the environment, should reconstruct knowledge body for sustainable situation. Fostering more new external knowledge via capability of AC improves innovation capability (Svetina and Prodan, 2008). Innovation can be better understood as a process in which the organization creates and defines problems and then actively develops new knowledge to solve them. Moreover, innovation produced by one part of the organization, in turn, creates a stream of related information and knowledge (Nonaka, 1994). Innovation is the multi-stage process whereby organizations transform ideas into new/improved products, services or processes, in order to advance, compete and differentiate themselves successfully in their marketplace (Gruenhagen and Parker, 2019). Innovations may provide new solutions to a problem in the form of a product or service; they occur within a social context. More importantly innovation is a process of creating, adapting, implementing and realizing the value from new ideas (Gruenhagen and Parker, 2019).

Turbulent and complicated condition in the environment of enterprises necessitates absorption of new external knowledge and information to create new values as innovation. Indeed, innovation, is one of the main factors contributing to the survival of an enterprise as well as the growth of economy (Benedetto *et al.*, 2008; Xiao and Qin, 2010). Consequently, enterprises rely on new external knowledge and information to preserve sustainable conditions and keep their situation in the market (Cohen and Levinthal, 1990; McKelvie *et al.*, 2008). In 1996, Keller suggested that developing countries, in manipulating technological knowledge, should consider both aspects of embracing new external knowledge and digesting it to commercial ends. Given the significant role that external knowledge plays in the survival of the enterprises, exploring how enterprises organize and appropriately apply new external knowledge for innovation is a considerably crucial issue (Zahra and George, 2002).

In this article, AC suggest as a fundamental capability through which a firm mediate the stream of new external knowledge and cumulates this stream of knowledge to in its own knowledge-base. It is further discussed that such capabilities are linked to capability in innovation. These characteristics are explained within the framework of the waterfall model. In this regard, all capabilities determined by organizational antecedents, that exert effective influence on this process are explained.

1. LITERATURE REVIEW

In 2008, Chang and Lee described this age as the age of information explosion when knowledge activities are considered a kind of a firm's intellectual property. Nowadays, firms recognize the flow of new external knowledge as an important phenomenon in the innovation process (Escribano et al., 2009). AC define as a routine process through which a firm continually absorbs streams of new external knowledge to reconstruct its own knowledge structure and apply it as technological knowledge. This stream of knowledge, in the AC's process, flows to create each new product, therefore, firms should be careful to consider environment to gain new external knowledge and information. In 2009, Fabrizio published an article that discusses the concept of AC in detail. He accepts that knowledge and information outside the boundaries of a firm is not open and free in the area to be absorbed, acquired and utilized in the firms simply without any effort. In other words, Fabrizio believes that if innovation was simply available or cheap, firms would do a lot of it. This means that new external knowledge should be recognized, understood, absorbed, conveyed and utilized (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998; Zahra & George, 2002; Liao et al, 2002; Zhixiong and Yuanjin, 2010) by a firm through professional members and skill workers in the relevant subject and by special parts of a firm (Fabrizio, 2009) to create new values (Cohen and Levinthal, 1990).

First of all, Cohen and Levinthal in 1990 founded the role of R&D and its effect on technical knowledge. They defined AC as a firm's ability to recognize the value of new information, assimilate it, and apply it for commercial ends. Following Cohen and Levinthal (1990), Zahra and George (2002) first presented a new model of AC and briefed it as a dynamic capability in two subsets, namely, potential AC and realized AC. Each capability comprises two abilities (1) the ability to acquire and assimilate new external knowledge and (2) the ability to transform and exploit new external knowledge. Zahra, et al. (2009) defined AC as the ability of a firm to recognize, build up, and utilize new external knowledge from outside of enterprise. They consider prior related knowledge and organizational knowledge as important basis that helps embrace and apply new ideas.

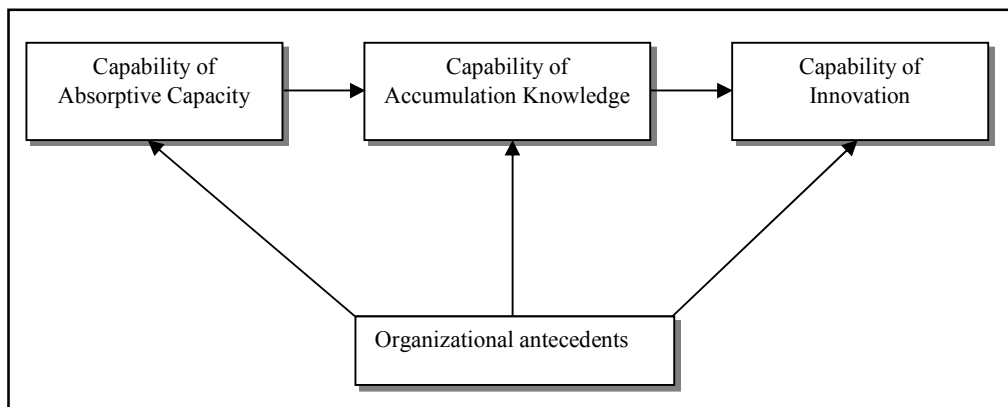
1.1 The Concept of Absorptive Capacity

A number of studies have found that new external knowledge can promote AC (Bosch et al., 1999; Vega-Jurado et al., 2008). Otherwise stated, capability of knowledge AC is always fostered with stream of new external knowledge (Zahra and George, 2002). In the process of AC, the flow of information and knowledge is recognized, absorbed, conveyed, applied and cumulated by endeavor of all levels of a firm to sustain and develop innovation. Capability of AC is the sum of abilities which enable a firm to acquire, absorb, transform and utilize new external knowledge (Zhixiong and Yuanjin, 2010). In this regard, AC is a firm's capability to deal with external knowledge (Schmidt, 2010) and a routine and strategic process, which a firm reconstructs, owns knowledge building and applies it for innovation.

Obviously, a firm succeeds efficiently when it can process and generate new external knowledge in dynamic and turbulent environments (Nonaka, 1994). Knowledge Spillovers are the unintentional transmission of knowledge that convey knowledge to firm's innovation efforts (Xiu-mei et al., 2007). Nowadays, organizations and scholars refer to AC as a kind of ability that improves capability to apply external knowledge, sustain innovation and jump towards it. Escribano et al. (2009) claims that the function of AC appears in conditions and situations with a high level of confusion and narrow existence of knowledge. They suppose that knowledge absorption process especially in this situation is highly significant. Firms with higher level of AC take advantage to access higher level of new external knowledge (Zahra and George, 2002; Zahra et al., 2009).

In this paper, there are three capabilities suggest, as Figure (1) shows, 1) linkage between AC, 2) accumulation of knowledge, and 3) innovation. Organizational antecedents in these activities is the baseline that determines how much a firm is able to organize and appropriately use new external knowledge.

Figure 1. Framework of linking between capabilities and organization antecedents



1.2 Waterfall Model of Absorptive Capacity

The Waterfall model of AC represents the process of new external knowledge AC through which knowledge is identified, acquired, assimilated, transformed, and utilized; thereafter the absorbed knowledge is cumulated and leads to innovation. But why waterfall design? The first and main reason to design waterfall model (Figure 2) is to show that the stream of new external knowledge, which flows, should spillover, and fertilized in each stage; and deliver stream of knowledge until the next stage does its own process. In other words, each step and stage has own function and affect from the last stage. Second, each stage as a box and phase shows abilities which a firm should have until it creates new value; this means that all the progress and stages have harmonization and work together until final phase. In such conditions, a firm must have all the abilities to perform the stages phase by phase and, in the meantime, harmonically together.

Third, input in this model is the stream of new external knowledge that passes each stage. That is the supply chain of knowledge is continuous and always nurtures AC. In the fourth stage, having accumulated knowledge, the firm is in the stage of knowledge spillover; the firm links and directs stream of knowledge to innovation as a consequence of flow of new external knowledge. Fifth, the stream of knowledge must be continually, without lameness of knowledge flow, reconstruct knowledge structure and create new values. Sixth, organizational antecedents support and determinant capability of AC (Fiol and Lyle, 1985; Walesh and Ungson, 1991; Turi et al., 2019), innovation (Mello et al., 2012; Dekoulou and Trivellas, 2017) and knowledge accumulation which show how much a firm has been successful in dealing with new external knowledge to appreciably use it for commercial ends.

1.3 The Elements of Absorptive Capacity

In 1990, Cohen and Levinthal stated that in out of boundaries and environment of firms, there are different and several information types that should be internalized to different knowledge bases. Cohen and Levinthal also mentioned that although all types of external knowledge in the environment are important but firms have to pay attention, absorb and monitor the type of information that can be useful and related to generation of innovation. In this way, past experiences showed that the path of gaining knowledge also facilitates assimilation (Zahra and George, 2002).

Vega-Jurado et al. (2008); Zahra and George (2002) argued that firms could transfer and exploit new external knowledge; they can acquire and assimilate new external knowledge if all abilities work together to promote AC. This paper explains various dimensions of AC to show how firms organize and manage new external knowledge by their abilities, which, in turn, leads to accumulation of new external knowledge and promotes the link between AC and innovation.

1.4 Knowledge Identification

Zhou and Wu (2010) mentioned that to develop innovation, a firm must first search and identify new external knowledge and evaluate alternative knowledge from different sources. In a similar vein, in 1990, Cohen and Levinthal defined this ability as evaluating new external knowledge which is possible through past experience and investment. Peters and Johnston (2009) in his definition of AC refers to it as a kind of ability to recognize the value of new information. They separated the ability to identify new external knowledge from the ability to acquire new external knowledge. In this stage, firms pay attention to and monitor environment to get information about new external knowledge in references such as magazines, internet, conference, customers, books, research centers and universities which may be useful to create new values. In other words, in this stage, firms should be able to verify new external knowledge that will be critical for innovation.

1.5 Knowledge Acquisition

Many scholars merge the ability to recognize with the ability to absorb new external knowledge and term it the acquisition of new external knowledge (Lane and Lubatkin, 1998; Zahra and George, 2002; Liao et al., 2002). A firm's ability to acquire new external knowledge which is crucial to exploit and create knowledge is knowledge acquisition (Lane and Lubatkin, 1990; Zahra and George, 2002, Liao et al., 2002; Zhixiong and Yuanjin, 2010). In 2002, Zahra and George also posited that acquisition of new external knowledge has five components, namely, prior investments, prior knowledge, intensity, speed and direction. They believe that these five components play a vital role in knowing the scope of search, perceptual schema, new connections, speed and quality of learning new external knowledge as far as capability of AC is concerned.

1.6 Knowledge Assimilation

Many scholars described the ability to assimilate new external knowledge as routine processes through which firms analyze, process, interpret and understand the information obtained from external resources (Szulanski, 1996; Lane and Lubatkin, 1998; Zahra and George, 2002; Zhixiong and Yuanjin, 2010). Cohen and Levinthal (1990) proposes that the ability to assimilate new external knowledge is based on knowledge characteristics, organizational or alliance dyad characteristics, and technological overlap. Zahra and George (2002), also suggests that the component of understanding plays a significant role in the processes of interpretation, comprehension and learning of new external knowledge.

1.7 Knowledge Transformation

Zhou and Wu (2010) claimed that having identified potentially useful knowledge, the firm must transfer that knowledge from the source and make editions to make it understandable to the firm. Lane and Lubatkin (1998); Zahra and George (2002); Liao et al (2002); Zhixiong and Yuanjin (2010), in this vein, considers the ability to transform new external knowledge as the ability to develop and refine the routines that facilitate combining the existing knowledge and the newly acquired and assimilated knowledge. Zahra and George (2002) mentioned that internalization and conversion are two main components of this ability for synergy and recodification of new external knowledge.

1.7 Knowledge Utilization

Zhou and Wu (2010) stated that the firm, following transformation of new external knowledge, must use and transform the knowledge into specific product designs that constitute product innovation. From Cohen and Levinthal (1990)'s viewpoint, utilization is applying new external knowledge to commercial ends based on technological opportunity and appropriability to protect innovation. In this respect, Zahra and George (2002); Bosch et al. (1999); Lane and Lubatkin (1998); Liao et al (2002); Zhixiong and Yuanjin (2010) described exploitation of new external knowledge as the ability to refine, extend, and leverage existing competencies or to create new ones by incorporating acquired and transformed knowledge into its operation. They consider usage and implementation as two components of this ability which play significant role in accessing core competencies and harvesting resources.

1.8 Knowledge Accumulation

This paper suggests that in the accumulation stage of knowledge, a firm through knowledge integration is able to create innovation. In other words, new external knowledge, in this stage, after process in capability of AC flourishes and as link is converted to new technological knowledge. Therefore, access to knowledge spillover is a prerequisite for innovation; and a firm has this competency to lead the stream of knowledge to the next capability. A firm's technological capability is developed over time and accumulated through its past experience (Zhou and Wu, 2010). Spillovers define as conjunction with AC result and technological capabilities or generation of a product (Udayagiri, 1991) and firms with first field of spillovers have a tendency to innovation (Xiu-mei et al. 2007). New knowledge is often generated through a cumulative process in which knowledge is added, deleted, transformed, modified or reinterpreted (Liu et al., 2009). In 2008, Chang and Lee postulated that through the integration and application of knowledge, firms can trigger innovative activities and capability of knowledge accumulation that exert effect on innovation.

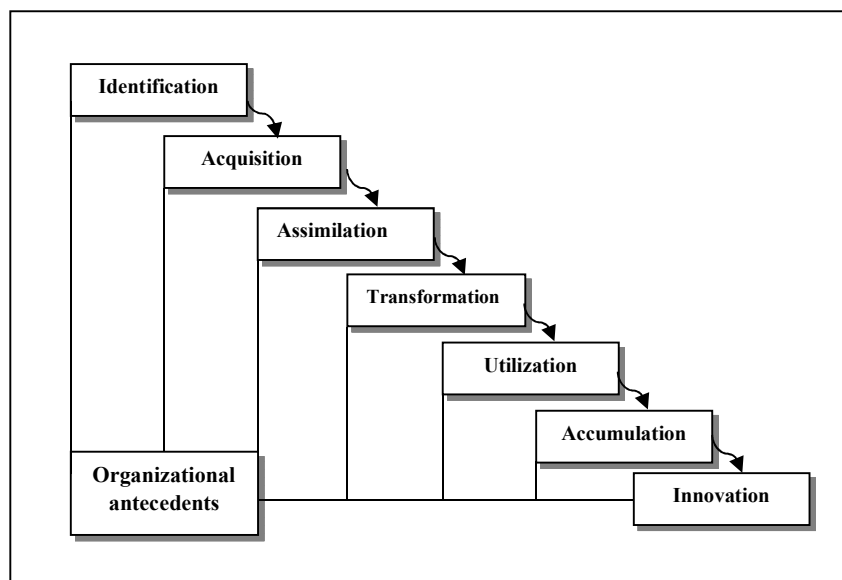


Figure 2. The waterfall model of absorptive capacity

Study of the relevant literature indicates that accumulation of experience and skills boosts the ability to absorb, recall and use new related knowledge. Hence, if new external knowledge is directly linked to activity, prior knowledge and skill, firms can easily assimilate it (Cohen and Levinthal, 1990).

The accumulation of technological knowledge increases the firm's ability to evaluate and use new technologies and skills in product innovation (Zahra and George, 2002). As a result, the firm can quickly identify new technological trends, experiment with emerging designs, and engage in product innovations beyond the current technological boundaries (Rosenkopf and Nerkar, 2001). Therefore, the accumulation of technological capabilities coincides with the process of explorative innovation (Zhou and Wu, 2010).

1.9 Innovation Capability

Researcher believed that innovation is accumulated knowledge that provides a guide to the search process (Helfat and Peteraf, 2003; Fabrizio, 2009). Galanakis (2006) defined innovation as creation of new products, processes, knowledge or services by using new or existing scientific or technological knowledge; this provides a degree of novelty either to the developer, the industrial sector, the nation or the world and succeeds in the marketplace. To Porter (1990) innovation is a new way of doing things which is commercialized.

1.10 Organizational Antecedents

It is necessary to know how organizational antecedents exert effect on aspects of AC and how organizational parameters determine the processes of knowledge absorption and accumulation of new external knowledge to innovate new values. In other words, the way a firm operates absorption of new external knowledge indicates a firm's stick power of new external knowledge (Cohen and Levinthal, 1990; Szulanski, 1996). Cohen and Levinthal (1990) discussed the internal mechanisms of a firm which have an influence on AC. A firm cannot buy and quickly apply new external knowledge to innovate new value because some type of knowledge should be digested and understood in R&D lab and applied for commercial ends. Zahra et al. (2009) defined AC as the ability of a firm to recognize, build up and utilize new external knowledge from outside the firm. Zahra and George (2002) consider prior related knowledge and organization knowledge as basic elements that significantly help embrace and apply new knowledge. AC also depends on its existing knowledge stocks, much of which is embedded in its products, processes and people (Liu et al., 2009).

Cohen and Levinthal (1991) stated that there are two levels of knowledge which affect a firm's AC, individual AC, and organizational AC that its depend on individuals' AC. Cohen and Levinthal (1990); Nonaka and Nishiguchi (2001) suggested that AC for assimilation and exploitation of knowledge should be applied in both individual, and organizational levels, with prior knowledge as a prerequisite. Zahra and George (2002) mentioned that prior knowledge and experience alongside more exposure to diverse and complementary affect acquisition and assimilation of new external knowledge. AC should be within the firm and its units at the same time (Cohen and Levinthal 1990). In 2010, Zhixiong and Yuanjin distinguished between abilities of employees in the antecedents of potential AC and realized AC also their abilities. An organization's AC, at first, depends on employees but in addition to the internal processes, combined effort of external mechanisms is required (Cohen and Levinthal 1990). A Firm's knowledge AC embraces both knowledge AC of a firm and its members; there is a cyclic process between organization and members to gain different kinds of knowledge (Zhixiong and Yuanjin, 2010). In other words, knowledge AC depends on the employees, level of education, training, experience and individual ability to assimilate new external knowledge. However, this individual ability is not AC; it belongs, as a whole, to the firm encompassing its employees, function, and departments (Cohen and Levinthal 1990). Individuals' AC in each firm can determined by their background and experience but AC of a firm is not the sum of AC of its members (Zhixiong and Yuanjin, 2010).

A firm's AC is related to prior relevant knowledge, that is, each firm which has high level in- house knowledge can do better process of AC to apply it in technology, therefore, a firm with this background and context can be successful in finding sources of knowledge (Escribano et al., 2009; Fabrizio, 2009; Vega-Jurado et al., 2008). In 2005, Gray suggested that Information and Communication Technologies as prior knowledge facilitate to exchange of knowledge and information between members of enterprises to identify and recognize new external knowledge.

Firm's departments must extend and combine their capabilities to intensify their ability of acquisition, assimilation, transformation and exploitation of new external knowledge (Jansen et al., 2005). Bosch et al. (1999) distinguished three types of combinative capabilities a firm has disposal as; 1) system capabilities in terms of direction, policies, procedures and manuals are which are often used to integrate explicit knowledge. These

capabilities are more formalized, explicit and changeable by management; 2) coordination capabilities that enhance knowledge absorption through relationship between members of a group. They contended that coordination capabilities are path dependent and are accumulated in a firm as a result of training, job rotation, natural liaison devices and participation; and 3) socialization capabilities that result from the firm's culture in terms of a system of ideas or inferred ideational codes lying behind the realm of observable events. These capabilities also give rise to social integration and can create mental prisons that prevent people from seeing important changes. Bosch et al. (1999) also mentioned that a firm reconfigures existing component knowledge located within its own industry environment or within other related industry environments.

In 2005, Jansen et al. explained organizational antecedents in detail and claimed that cross-functional interfaces, participation in decision-making and job rotation have positive effect on acquisition and assimilation of new external knowledge; formalization, routinization, connectedness and socialization tactics, on the other hand, exert negative effect on acquisition and assimilation of new external knowledge. Furthermore, cross-functional interface, job rotation, formalization, routinization, connectedness and socialization tactics positively affect transformation and exploitation of new external knowledge, but participation in decision-making carries negative effect (Jansen et al., 2005).

Vega-Jurado et al. (2008) specifies three basic categories that play a role on AC: 1) organizational knowledge that embraces the set of skills, knowledge, and experience a firm possesses. It is determined by the firm's prior knowledge base, the accumulated experience with knowledge search, the individual skills of its employees, and its R&D activities; 2) formalization refers to the extent to which procedures, rules, and instructions govern organizational processes; in other words, it reflects the degree to which behaviors are programmed by formal explicit rules. Formalization may have a dual influence on AC. On the one hand, it may increase the efficiency of knowledge acquisition by laying down general guidelines tailored to the needs of the firm; on the other hand, it may hinder the transformation and exploitation of knowledge, insofar as these are highly cognitive dimensions in which rigid antecedents are a serious impediment; and 3) social integration mechanisms which enhance the absorption of knowledge by encouraging interaction between the different members of a group, and thus are most effective in activities that require a considerable cognitive level, such as transformation and exploitation (Vega-Jurado et al., 2008).

CONCLUSION

AC is kind of ability which needs great investment to assure continual innovation and is basically determined by a firm's abilities. In the process of absorbing new external, knowledge, all abilities should spillover and fertilize flow of new external knowledge to cumulate knowledge and flourish technological knowledge. Clearly this process should occur for each innovation and not only for once, because a firm, for sustainable competitive advantage, always needs to innovate new values. Escribano et al. (2009), in this regard, conceives that firms, to rival in the environment, reconstruct knowledge body for sustainable situation.

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