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Validation of an instrument to measure absorptive capacity

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ABSTRACT

Absorptive capacity is an ability firms should develop if they wish to adapt to changes in an increasingly competitive and changing environment and to achieve and sustain competitive advantage. Despite the increase in literature on absorptive capacity, some ambiguity remains in determining the dimensions that shape the construct. Thus, no measurement instrument can be adapted to these dimensions. The aim of this paper is to contribute to the literature on absorptive capacity by using a resource-based view to present an alternative measurement instrument for absorptive capacity. This instrument differentiates between the phases of acquisition, assimilation, transformation and exploitation of knowledge, as well as between the two dimensions of absorptive capacity (potential and realized), to reduce the problem of measuring and identifying the dimensions that shape this important construct. The instrument's validity and reliability are guaranteed and have been tested using data from 168 Spanish organizations.

1. Introduction

Absorptive capacity is initially defined as an ability to recognize the value of new information, assimilate it, and apply it to commercial ends (Cohen and Levinthal, 1990). It is one of the fundamental learning abilities that firms can develop to detect knowledge and information outside the organization that may be useful to them and then to internalize and adapt that information to their specific needs and exploit it for market goals. It depends on the level of prior related knowledge that the organization possesses and is developed cumulatively, through a long process of research and knowledge accumulation. Thus, organizations that possess a good knowledge base in a specific field usually have high absorptive capacity and will be able to evaluate and act on the new information or new ideas that are developed in this field of knowledge (Cohen and Levinthal, 1990; Zahra and George, 2002).

Of all possible resources firms can possess, their knowledge base will be one of the most strategic for obtaining a competitive advantage (Grant, 1996; Gupta and Govindarajan, 2000). If the probabilities of success of a specific project change due to new discoveries outside the firm's limits, firms with greater absorptive capacity will be sensitive to these changes and adjust their research efforts quickly in accord with the new information.

Absorptive capacity is thus a variable used with great frequency in research on collaboration strategies between different organizations (e.g. Dyer and Singh, 1998; Johnson et al., 2004; Koza and Lewin, 1998; Lane and Lubatkin, 1998). Through learning alliances, firms can develop capacities quickly and minimize their exposure to technological uncertainties by acquiring and exploiting the knowledge developed by others (Grant and Baden-Fuller, 1995).

Absorptive capacity implies learning and acting on scientific discoveries and technological activities outside the organization's limits (Deeds, 2001; Sun and Anderson, 2010). It enables the firm to acquire knowledge and use it effectively, strongly affecting the firm's ability to innovate, adapt to changes in its environment and be competitive (Daghfous, 2004; Escribano et al., 2009). It is even more important as a multidisciplinary concept, serving to link or mediate between related fields of knowledge, such as organizational learning, knowledge management and innovation management (Lane et al., 2002; Van den Bosch et al., 2003).

However, the intangible nature of this construct makes it difficult to conceptualize, further complicating the definition of the dimensions that shape it. Both aspects require extremely careful study. The resource-based view offers a valuable explanation for the fact that intangible resources have been converted into the key to competitive success for many firms (e.g. Barney, 1991; Eisenhardt and Martin, 2000; Grant, 1991; Nelson, 1991; Peteraf, 1993; Prahalad and Hamel, 1990; Teece et al., 1997; Wernerfelt, 1984). Intangible resources can be defined as assets that belong to an organization and that are difficult to evaluate from an accounting perspective (Itami, 1987). The resource-based view analyzes the role these intangible resources play in achieving and maintaining entrepreneurial competitive advantage. This analysis requires strategic study of how to identify, measure and evaluate the resources and capabilities available to the firm. But the greatest advantage of the resource-based view is also its greatest drawback. Intangible assets have a greater potential to contribute to a sustainable competitive advantage over time because they are difficult

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for competitors to imitate (Teece, 2000) but, they are also difficult to measure and evaluate, and sometimes to detect even in the very firm that possesses them (Carmeli, 2000).

As mentioned above, absorptive capacity is one of these intangible assets. Absorptive capacity is a good source of sustainable competitive advantage over time (Cohen and Levinthal, 1990; Dyer and Singh, 1998; Haro-Domínguez et al., 2007), but it is no exception to the measurement problem that intangible resources pose for firms. In the current scientific literature, this capacity has been defined in multiple ways. Not only is there no consensus about the number of dimensions or phases that compose the construct of absorptive capacity, but no solidly tested measurement instrument has been developed to differentiate the phases of the process by which the unit that learns absorbs knowledge from the unit that teaches (Todorova and Durisin, 2007; Zahra and George, 2002). Since the 1990s, many scientific articles have developed the theoretical foundations of absorptive capacity, but even now there is a clear lack of empirical research (Lane et al., 2006; Lichtenthaler, 2009; Murovec and Prodan, 2009).

Given the foregoing, this study attempts to solve the deficiencies in the content of the construct by specifying its theoretical domain and establishing unequivocally the dimensions that compose it. To achieve this, the study performs an exhaustive analysis of the prior scientific literature as a basis for obtaining a valid and reliable measurement instrument for absorptive capacity, especially useful when strategic alliances are generated or cooperation between firms arises. Given the need to guarantee rigorous empirical validation of the measurement instrument, the study evaluates three fundamental issues: content validity, concept validity, and reliability of the scale. The measurement techniques used in the literature to date are reviewed. Subsequently, a validation method of exploratory and confirmatory scales is applied, using the model of structural equations to provide methodological guarantees.

To achieve the objectives, the investigation is structured as follows. Section 2 contains the literature review and a conceptual framework of the definitions and dimensions of absorptive capacity. Section 3 details the fieldwork undertaken to develop the measurement instrument, describing the work procedure and the sample. Section 4 analyzes the scale's validity in terms of content, concept, and reliability. Finally, Section 5 develops and analyzes the results obtained, outlines limitations and proposes future lines of research.

2. Literature review and conceptual framework

2.1. Literature review

Many studies published to date agree that absorptive capacity is a multidimensional construct (e.g. Cohen and Levinthal, 1990; Lane and Lubatkin, 1998; Todorova and Durisin, 2007; Xia and Roper, 2008; Zahra and George, 2002) but establish a different number of dimensions with different content. There is no consensus among researchers in establishing the number of phases that compose the construct to be studied.

Cohen and Levinthal (1990, p. 128) define absorptive capacity as "an ability to recognize the value of new information, assimilate it, and apply it to commercial ends."

The authors establish three dimensions, corresponding to the three abilities that derive from this definition. The first is the ability to recognize the value of new external knowledge. To enable effective and creative use of the new knowledge by the learning firm, the factors that facilitate recognition of the value of external knowledge must possess both some prior basic knowledge common to the new knowledge and some part of the teaching firm's knowledge that is completely different.

Second, the firm must be able to assimilate the new external knowledge. Once the firm has recognized useful outside knowledge, it must determine how to internalize it. It will be easier for one firm to assimilate knowledge from another if the two firms' knowledge processing systems are similar.

Third, the firm must be able to commercialize the new external knowledge. The more experience the organizations involved have in solving similar problems, the easier it will be for the student firm to find a commercial application for the recently assimilated knowledge.

Various subsequent researches relate directly to the definition of the term yet establish different numbers of dimensions. Since the first definition of the concept has been changing based on improvements introduced by subsequent studies, it is logical to conclude that the dimensions considered change based on the definition adopted.

Lane and Lubatkin (1998) start from the definition of Cohen and Levinthal (1990) and establish the same three dimensions, stressing that the first dimension is the similarity of the scientific, technical or academic knowledge, the know-what part of the student and teacher firms' knowledge bases. The second dimension is the know-how part of its knowledge bases. The final dimension, which focuses on the similarities of the firms' commercial objectives, is the know-why part of their knowledge.

The subsequent study by Lane et al. (2001) expands the components of the three dimensions, improving them considerably in the context of international joint ventures. The first dimension, which they label the ability to understand the knowledge, depends on the trust between the parties, their cultural compatibility, the prior related knowledge base, and the relation between the two parties' business.

The second dimension, ability to assimilate new knowledge, depends on flexibility and adaptability, support from management, training, and the formal objectives and specialization of the parties involved in the knowledge exchange. Finally, the third dimension, ability to apply external knowledge, derives from the effect that the business strategy and training competences of the joint venture have on both parties. The authors relate this third dimension of absorptive capacity to the performance of the joint venture and not to the knowledge learned, as was the case with the first two dimensions.

After the empirical development of the study, Lane et al. (2001) leave open the possibility that absorptive capacity is composed of only two different dimensions. This is the case because their conclusions lead them to assert that the first two components—ability to understand and ability to assimilate external knowledge—are independent as well as different from the third component, ability to apply this knowledge. Therefore, absorptive capacity could have two dimensions. These results are consistent with the two-dimensional concept of the construct previously established by Heeley (1997), who dimensionalized absorptive capacity by considering only two parts, acquisition of external knowledge and its dissemination within the firm. The third phase identified by Cohen and Levinthal (1990)—exploitation of information—will depend on the firm's technical capacities. The greater a firm's technical capacity, the greater its ability to understand and assimilate external knowledge (to develop the first two dimensions, which are those it considers most important), and the greater the benefit to be obtained from the external knowledge.

Zahra and George (2002, p. 198), in contrast, distinguish four dimensions, which coincide with the phases of absorptive capacity included in their definition. These authors indicate that absorptive capacity "is a set of organizational routines and strategic processes by which firms acquire, assimilate, transform, and exploit knowledge for the purpose of value creation." Thus, the first dimension is acquisition. This dimension was originally identified by Cohen and Levinthal (1990) as the recognition of value, even if other researchers have used the term acquisition more often. Zahra and George

(2002) redefine this term, emphasizing not only evaluation of the use of the knowledge but also its transfer from one firm to the other.

The second dimension is assimilation. In this phase, the firm's goal is to understand the external knowledge through its own specific routines. To assimilate the knowledge and obtain advantages from it, the organization's members must interpret and comprehend this knowledge in order to finally learn it.

The third dimension is transformation. Transformation capacity is the internalization and conversion of the new knowledge acquired and assimilated. It seeks to combine existing with newly acquired knowledge and consists of the ability to recognize two apparently incongruent sets of information and combine them to achieve new cognitive structures. This capacity is related to the recognition of entrepreneurial opportunities.

The fourth and final dimension is exploitation. This dimension is strategic for a firm, as it generates the results after the effort to acquire, assimilate and transform the knowledge. Exploitation is the development of routines to apply the knowledge, using it to create new goods, systems, and processes (i.e., new organizational forms) and improving existing competences, or even completely new competences.

Each dimension plays a different but complementary role in explaining how absorptive capacity can influence the organizational results. The dimensions are combined into two subsets with different potentials for creating value—potential and realized absorptive capacity.

Potential capacity enables the firm to be receptive to external knowledge, that is, to acquire, analyze, interpret and understand this knowledge. It involves the dimensions of knowledge acquisition and assimilation. Realized capacity reflects the firm's ability to transform and exploit the new knowledge, incorporating it, with existing knowledge, into its operations. This capacity is thus determined by the dimensions of knowledge transformation and exploitation. The mere fact that a firm evaluates and acquires knowledge from the exterior does not guarantee that it will exploit this knowledge.

Another study, performed by Jansen et al. (2005), obtains results along the same lines. The authors start from the four dimensions proposed by Zahra and George (2002) and conclude that absorptive capacity has two different components that correspond to the potential and realized absorptive capacity described by Zahra and George (2002).

Todorova and Durisin (2007) propose reconceptualizing the term absorptive capacity, making some changes in the definition given by Zahra and George (2002) and thus in the construct's dimensions. They first propose a return to calling the first ability or dimension of the absorption process the ability to "recognize the value" of new external knowledge, as had Cohen and Levinthal (1990). This label stresses recognition as a first crucial step in acquiring new external knowledge and is a much clearer term, as it is based on the idea originally proposed by Cohen and Levinthal (1990) that, if there is no prior knowledge, organizations will not be able to evaluate the new information and thus will not be able to absorb it.

Second, since the process of transformation assumes understanding situations and ideas that are initially perceived as incompatible with the current knowledge frameworks, and since firms could also acquire new knowledge that would be more compatible with the prior knowledge, the authors assert that transformation represents an alternative and not a subsequent step to assimilation. The transformation only occurs with knowledge that is too new to be assimilated as it is. Thus, the four dimensions identified by Todorova and Durisin (2007) are recognizing the value, acquiring the new external knowledge, assimilating or transforming the knowledge, and exploiting it.

Finally, Lichtenthaler (2009) supports distinguishing three complementary learning processes within absorptive capacity: exploratory learning that comprises the stages of recognizing external knowledge and assimilating this knowledge; transformative learning that comprises the stages of maintaining assimilated knowledge and reactivating this knowledge; and exploitative learning that comprises the stages of transmuting and applying the assimilated knowledge. Although these stages have been analyzed in previous research (i.e. Lane et al., 2006; Todorova and Durisin, 2007; Zahra and George, 2002), the way of grouping them is different.

The different dimensions that compose absorptive capacity according to the different researchers' contributions are summarized in Table 1.

Given the lack of consensus in the scientific literature, it is necessary to develop the empirical work that will permit determining the precise number of dimensions that form absorptive capacity in the context of Spanish firms. Although the main researchers clearly disagree on the number of dimensions that compose absorptive capacity, the results point to a two-dimensional construct, as various authors ultimately combine different numbers of initial dimensions into two subsets (e.g. Heeley, 1997; Jansen et al., 2005; Lane et al., 2001; Zahra and George, 2002).

2.2. Conceptual framework

Once the main contributions of the most significant researchers have been analyzed, absorptive capacity can be defined as *the organization's relative ability to develop a set of organizational routines and strategic processes through which it acquires, assimilates, transforms and exploits knowledge acquired from outside the organization in order to create value*.

This new definition takes into account the four phases of development of absorptive capacity considered by Zahra and

Table 1
Main dimensions of absorptive capacity.
Source: Developed by the authors.

Author	1st dimension	2nd dimension	3rd dimension	4th dimension
Cohen and Levinthal (1990)	Recognize the value	Assimilate	Commercialize	
Heeley (1997)	Acquire	Disseminate		
Lane and Lubatkin (1998)	Recognize the value	Assimilate	Commercialize	
Lane, Salk and Lyles (2001)	Understand	Assimilate	Apply	
Zahra and George (2002), Jansen et al. (2005)	Potential		Realized	
	Acquire	Assimilate	Transform	Exploit
Todorova and Durisin (2007)	Potential		Realized	
	Recognize	Acquire	Assimilate or Transform	Exploit
Lichtenthaler (2009)	Exploratory learning	Transformative learning	Exploitative learning	
	Recognize and assimilate	Maintain and reactivate	Transmute and apply	

George (2002). In addition to being very useful because they can be divided into potential and realized absorptive capacity to study the exploration and exploitation of knowledge, these phases possess the relative character of the construct proposed by Lane and Lubatkin (1998). Further, although this study is developed at the organizational level, the definition proposed may be applied to investigating any unit that learns relative to any unit willing to teach its knowledge, be they individuals, work groups, organizations, countries, etc.

Taking into account the foregoing contributions, the dimensions that compose the construct can be defined as follows:

Acquisition capacity is a firm's capacity to locate, identify, evaluate and acquire external knowledge that is important to the development of its operations (e.g. Lane and Lubatkin, 1998; Zahra and George, 2002).

Assimilation capacity is a firm's capacity to comprehend the knowledge (or information) brought from outside the organization. That is, it is the ability to analyze, classify, process, interpret, and ultimately internalize and understand this knowledge (e.g. Cohen and Levinthal, 1990; Szulanski, 1996).

Transformation capacity is a firm's capacity to facilitate the transfer and combination of prior knowledge with newly acquired or assimilated knowledge. It consists of adding or eliminating knowledge and of interpreting and combining existing knowledge in a new and different way (e.g. Jansen et al., 2005; Todorova and Durisin, 2007).

Exploitation capacity is a firm's capacity to incorporate the knowledge acquired, assimilated and transformed in its operations and routines for the firm's application and use. This capacity will give rise to the creation or improvement of new goods, systems, processes, organizational forms and also competences (e.g. Lane et al., 2001; Zahra and George, 2002).

These dimensions will be analyzed in the empirical study presented in the rest of the article.

3. Methodology, sample and procedure

The first necessary step in an empirical study is selecting the population to be analyzed. The population for this study consisted of Spanish firms from the automotive and chemical sectors. This population was chosen to concentrate the geographical environment in a national territory, ensuring a homogeneous economic, political, sociocultural, technological and legal framework for all firms in the study. Such a framework minimizes the impact of the variables that cannot be controlled in the empirical research (Adler, 1983). The automotive and chemical sectors were chosen because they are considered to be highly innovative, an essential factor given the content of the study. However, firm size is not a discriminant variable in the choice of the population, as the level of analysis of absorptive capacity takes place in relation to the student–teacher relationship. Some authors even consider the two levels of analysis simultaneously (i.e. Yeoh, 2009). Small firms are thus not excluded from this research (Lane and Lubatkin, 1998).

Taking into account the prior considerations, a reliable list of firms from which to obtain the sample was developed. The selection was taken from AMADEUS (2004), a financial database containing information on 150,000 public and private firms from 26 European countries. AMADEUS includes all kinds of firms except those belonging to the financial and insurance sectors. It provides general information on organizations (name, address, phone numbers, sector of activity, etc.) and accounting information (balance, the name of the main stockholders, affiliated companies, etc.).

All Spanish firms with National Classification of Economic Activities (CNAE) 24 from the chemical industry and CNAE 34 and 35, firms manufacturing transportation materials, were chosen from the database. These activities are strategic sectors in the Spanish economy in which prior research shows that absorptive capacity is essential (e.g., Lane and Lubatkin, 1998; Nooteboom et al., 2007). These sectors share the importance of investing in R&D and innovation, but they also differ profoundly in some key characteristics, such as stage of industry development, and importance of exploration vis-à-vis exploitation. Testing the hypotheses in different sectors enables assessment of how far the role of absorptive capacity remains across sectors, enhancing generalization of the results (Gilsing et al., 2008). The information was then purified to eliminate possible duplications caused by the inclusion of affiliates in the database. The final study population was composed of 5163 firms.

Drawing on the knowledge about key dimensions of this investigation, previous contacts with interested managers and scholars, and new interviews with managers and academics interested in the topic and familiar with the chemical and automotive sectors, the authors developed a structured questionnaire to investigate how organizations face these issues. The responses of the interviewees in this first stage were omitted from the subsequent analysis of the survey data.

As in previous studies on absorptive capacity (Garci´a Morales et al., 2007; Zahra and Hayton, 2008), the key informants in this study were Chief Executive Officers (CEOs). The informants chosen were to be knowledgeable about the issues being researched and able and willing to communicate about them. The interviewees were requested to not answer unless they could directly observe or had knowledge of the variables in question (Kozlowski and Klein, 2000). This decreased the percentage of responses but increased the reliability and validity of the questionnaires received (Li et al., 2007).

CEOs also play a major role in informing and molding the variables under study by determining the types of behavior that are expected and supported (Baer and Frese, 2003). Further, although numerous actors may be involved in the management process, the CEO is ultimately responsible for plotting the organization's direction and plans and guiding the actions to achieve them (Westphal and Fredrickson, 2001). CEOs receive information and knowledge from a wide range of departments and are thus a valuable source for evaluating the organization's absorptive capacity (Garci´a Morales et al., 2007). The same type of informant was chosen to keep the level of influence among organizations constant, increasing the validity of the variable measurements (Glick, 1985).

The sample was selected by means of a system of random sampling within the chemical and automotive industries. Surveys were mailed to the 1000 selected organizations along with a cover letter in late November 2004. 36 questionnaires were returned due to unknown address and were not replaced with others. This method was used because it reached a greater number of organizations at a lower cost, exerted less pressure for immediate reply, and provided the interviewees with a greater sense of autonomy. The cover letter explained the goal of the study and offered recipients the possibility of receiving the results once the study was completed. To reduce possible desirability bias, the cover letter promised to keep all individual responses completely confidential and confirmed that the analysis would be restricted to an aggregate level that would prevent the identification of any organization. Interviewees were informed that they would receive the questionnaire soon and reminded that the person chosen to answer it must have knowledge of the variables in question, even though this would mean receiving fewer responses.

Subsequently, the questionnaire was sent by email to the remaining 964 firms. They had the option of completing the questionnaire by ordinary mail or online through a web page designed for this purpose.

The firms were contacted in this way until May 2005. 170 questionnaires were returned, of which 2 were eliminated for

Table 2
Technical data sheet for the study.

Sector	Chemical	Automotive	Total
Sample size	689	275	964
Response size (response rate)	121 (17.56%)	47 (17.01%)	168 (17.43%)
Geographical location	Spanish firms		
Methodology	Questionnaire. Ordinary mail and email		
Sample error	3.47%		
Response rate	17.43%		
Confidence level	95%, $p-q=0.50$; $z=1.96$		
Person to whom survey addressed:	CEO		
Period of data collection	From November 2004 to May 2005		

responding to fewer than 95% of the questions formulated. Thus, from a sample of 964 firms contacted, a response rate of 17.43% was obtained, similar to other research on absorptive capacity (Garcı´a Morales et al., 2007; Lin et al., 2002; Nieto and Quevedo, 2005; Zahra and Hayton, 2008). By activity sector, 71.48% of the firms surveyed belong to the chemical industry and 28.52% to the automotive industry. 87.6% are SMEs (Small and Medium Enterprises) and 12.4% large enterprises, a proportion that reflects the entrepreneurial reality in Spain. When the research was conducted, the European Commission's definition of SME was based on companies with fewer than 250 employees with either an annual turnover not exceeding €50 million or an annual balance sheet total not exceeding €43 million. Table 2 summarizes the technical data sheet for the study.

A recurring problem in studies that use a sample is possible non-response bias. The technique most often used to confirm whether this problem occurs is to study whether there are significant differences between the firms that respond first and those that answer at the end of the period. The underlying idea is that firms that answer later tend to be more similar to those that do not respond (Armstrong and Overton, 1977). With the data available, an ANOVA analysis was performed to study the differences between earlier and later respondents. Analysis also determined whether there were significant differences between the firms based on the sector to which they belonged, number of employees and sales volume (the last two factors together determine the size of the organization), and the responsibility of the person who answered the questionnaire. In all cases, there were no significant differences. Thus, there was no risk that the sample would be biased relative to the population.

4. Validation of the measurement scale for absorptive capacity

To validate the measurement scale constructed, its validity and reliability are analyzed. For validity, content validity was analyzed first to evaluate the instrument's capacity to include the content and reach of the construct and its dimensions, ensuring that the scale really represents the construct measured. Concept validity was then studied, based on a factor analysis of the items that form the measurement instrument and that determine the underlying variables and relations between the scale items. Establishing the scale's reliability involves confirming its internal consistency, evaluating the rigor with which the items of the construct are measured. Analysis must also confirm that the scale fulfils the property of parsimonious parametrization—that it contains a small number of items that carry relevant but not redundant information.

4.1. Content validity

Absorptive capacity was measured as both a unidimensional and a multidimensional construct. The problem of consensus in measuring occurred as a direct result of the lack of agreement in determining the dimensions that compose the construct.

From the earliest to the most recent studies, many authors have opted to measure absorptive capacity directly, considering it a unidimensional construct. The most popular measure of the construct was the R&D effort made by the organization, normally measured by R&D expenditure divided by annual sales (e.g. Cohen and Levinthal, 1990; Stock et al., 2001; Tsai, 2001; Zahra and Hayton, 2008). This measure is too simple, however, and cannot reflect the richness of the construct in its totality (Zahra and George, 2002).

Other authors have measured the construct using data taken from a single variable or from two variables closely related to investment in R&D. These include, for example, the firm's possession of its own R&D departments with full-time personnel (Veugelers, 1997), percentage of technical and professional personnel over the total number of employees (Luo, 1997), R&D expenditure and number of patents (George et al., 2001), level of technological overlap between the future members of an alliance before the agreements takes place (Mowery et al., 1996), knowledge management of information technology (IT) of business processes (Boynton et al., 1994), total number of publications per dollar spent on research annually (Cockburn and Henderson, 1998), R&D effort in training personnel (Petroni and Panciroli, 2002), the kinds of knowledge sought outside the organization relative to the organization's own knowledge bases (Shenkar and Li, 1999), the existence of formal R&D laboratories and the regularity of R&D activities (Becker and Peters, 2000), and R&D activities aimed at developing new knowledge and other activities such as knowledge intelligence and knowledge dissemination (Spithoven et al., 2010).

Some other researchers have chosen a larger set of variables to measure the construct. Szulanski (1996) measures absorptive capacity as a global construct using a scale of nine items and without differentiating between its phases. Mangematin and Nesta (1999) use a set of factors that include R&D expenditure, number of researchers in the organization, regularity of R&D activities, number of R&D laboratories, links with public research institutes, number of publications and number of patents. Nieto and Quevedo (2005) identify the main factors that influence the accumulation of absorptive capacity in a firm as a basis for measurement. They use items reflecting communication with the external environment, the organization's level of knowledge and experience, diversity and coincidence between structures of knowledge, and strategic position.

Finally, another group of researchers have measured absorptive capacity as a process, taking into account a varying number of dimensions where, as discussed above, there is no consensus about the number of phases that compose the construct. Thus, absorptive capacity has been measured through acquisition of external knowledge and dissemination of knowledge within the firm (Heeley, 1997; Liao et al., 2003); assimilation and replication of the new knowledge obtained (Chen, 2004); adaptation, production

and application of knowledge (Lin et al., 2002); comprehension, assimilation, and application of the knowledge (Lane et al., 2001); recognition of the value, assimilation and application of the knowledge (Thuc Anh et al., 2006); and acquisition, assimilation, transformation and exploitation of the knowledge (Jansen et al., 2005).

Table 3 summarizes the instruments for measuring absorptive capacity that are used most often by the most respected researchers.

This study seeks to measure absorptive capacity by differentiating between the dimensions of acquisition, assimilation, transformation and exploitation of knowledge. It will later combine the first two and the last two variables to confirm whether this combination can obtain the organizations' potential and realized absorptive capacity.

The procedure frequently used to examine content validity consists of observing whether the process carried out in the construction of the scale adheres to the criteria suggested in the prior published literature and whether this literature uses scales developed by other authors that have already been contrasted in empirical scientific studies. The scale developed here has content validity, because the main measurement tools have been reviewed and because the choice of the determining phases and dimensions of absorptive capacity was taken from the work of Zahra and George (2002). Further, measuring each of these phases and the two dimensions to formulate the questionnaire, the study took into account items published in prior scientific research by Kale et al. (2000), Kohli et al. (1993), Lane et al. (2001) and Szulanski (1996). These authors view absorptive capacity as an abstract, intangible concept that can thus be measured through the internal mechanisms or factors that influence it, that is, that make it occur. One must distinguish between the measurement of the construct and the measurement of its antecedents and consequences in order to specify its operationalization (Van den Bosch et al., 2003). For this reason, this study proposes to revise the routines, the mechanisms and the activities of each phase of absorptive capacity as the tools with which to develop the constructs measured. The five studies cited on which the research is grounded come from very prestigious scientific journals, such as "Strategic Management Journal", "Journal of Marketing Research" and "Academy of Management Review." All are included in the ISI database (Institute of Scientific Information), which provides the widest coverage of the most important and influential journals in the research community. Thus, all of the works cited are ranked by the JCR (Journal Citation Reports) with the highest impact indexes.

For content validity, this investigation begins with items already tested in other research and uses analyses performed by experts and academics. This study developed a prior exploratory program of in-depth interviews with businesspeople, specifically with twelve general directors representative of the sectors under study (seven from the chemical sector and five from the automotive sector). The directors were chosen at random from the firms composing the sample to help to identify each of the questions that the different dimensions include in the most accurate way and without creating errors. The suggestions received were incorporated into the scale.

The resulting scale contains 18 items. It is a 7-point Likert scale, where 1 takes the value of "*totally disagree*" and 7 "*totally agree*." The scale is shown in the Appendix.

Table 3
Most representative measurement factors for absorptive capacity.
Source: Developed by the authors.

Authors	Measurements used
Becker and Peters (2000)	The existence of one or more of firm's own R&D laboratories and regularity of internal R&D activities
Boynton et al. (1994)	Knowledge management of information technology (IT) in business processes
Chen (2004)	Scale of 5 items to measure the firm's ability to assimilate and reproduce the new knowledge obtained from external sources
Cockburn and Henderson (1998)	The total number of publications based on dollars spent on research annually
Cohen and Levinthal (1990), Stock et al. (2001), Tsai (2001); Zahra and Hayton (2008)	R&D effort (R&D expenditure/annual sales)
George et al. (2001)	Expenditure on R&D (to measure the ability to acquire knowledge) and the number of patents (to measure the ability to apply the knowledge)
Heeley (1997)	Scale of 24 items to measure the acquisition of new knowledge from outside the firm and the dissemination of this knowledge within the firm
Jansen et al. (2005)	Scale of 21 items used to measure potential absorptive capacity (acquisition and assimilation of knowledge) and realized absorptive capacity (transformation and exploitation of knowledge) (scale included in the study)
Lane et al. (2001)	Adapt the scales from other related studies and create a new scale of 24 items to measure the comprehension, assimilation and application of knowledge (included in the study)
Lin et al. (2002)	Scale formed of 15 items used to measure capacity for adaptation, production and application of knowledge
Luo (1997)	Percentage of technical and professional personnel divided by the total number of employees in the organization analyzed
Mangematin and Nesta (1999)	R&D expenditure, number of researchers, duration of R&D activities, number of R&D laboratories, links with public research institutes, number of publications, and number of patents
Mowery et al. (1996)	Level of technological overlap between the future members of an alliance before the agreement takes place (measured as the number of patents of firm *j* cited in the patents of firm *i*/total number of citations present in the patents of firm *i* before the agreement takes place between firms *j* and *i*)
Nieto and Quevedo (2005)	Scale formed of 32 items to measure communication with the environment, the organization's level of knowledge and experience, the diversity and coincidence of structures of knowledge and strategic position
Petroni and Panciroli (2002)	R&D effort (expenditure on R&D/annual sales) and the effort in training personnel (expenditure on training personnel/annual sales)
Shenkar and Li (1999)	Set of binary variables used to measure organizations' propensity to transfer knowledge from their allied partners relative to their own knowledge bases
Spithoven et al. (2010)	R&D activities aimed at developing new knowledge and other activities such as knowledge intelligence and knowledge dissemination activities
Szulanski (1996)	Scale formed of 9 items to measure global absorptive capacity (scale included in the study)
Thuc Anh, et al. (2006)	Development of a scale that measures absorptive capacity as a multidimensional construct that incorporates organizational issues as well as human capital
Veugelers (1997)	Existence of the firm's own R&D departments with full-time personnel

4.2. Concept validity

To determine the underlying dimensions of absorptive capacity, an exploratory factor analysis was performed, first using the method of extraction of principal components with Varimax rotation with Kaiser normalization and setting the number of factors at four. The results are shown in Table 4.

As can be seen, there are four phases underlying absorptive capacity, and all of the items except COMMON LANGUAGE and COMPLEMENTARITY have significant loadings on a single factor. Items INTERACTION, TRUST, RESPECT, FRIENDSHIP and RECIPROCITY measure the phase of external knowledge acquisition. Items COMMON LANGUAGE, COMPLEMENTARITY, SIMILARITY, COMPATIBILITY1, and COMPATIBILITY2 measure the assimilation phase. Items COMMUNICATION, MEETINGS, DOCUMENTS, TRANSMISSION, TIME and FLOWS determine the transformation phase, and RESPONSIBILITY and APPLICATION determine the phase of knowledge exploitation.

In a second exploratory analysis, the study proceeded in the same way, except that this time it set the number of factors at two. The results now coincide with the two dimensions of absorptive capacity, shown in Table 5.

Table 4
Rotated component matrix for four factors.

Items	Factor 1	Factor 2	Factor 3	Factor 4
INTERACTION	0.838			
TRUST	0.867			
RESPECT	0.828			
FRIENDSHIP	0.648			
RECIPROCITY	0.785			
COMMON LANGUAGE	0.505		0.510	
COMPLEMENTARITY	0.518		0.519	
SIMILARITY			0.702	
COMPATIBILITY1			0.794	
COMPATIBILITY2			0.806	
COMMUNICATION		0.422		
MEETINGS		0.884		
DOCUMENTS		0.769		
TRANSMISSION		0.810		
TIME		0.753		
FLOWS		0.778		
RESPONSIBILITY				0.824
APPLICATION				0.766

Table 5
Rotated component matrix for two factors.

Items	Factor 1	Factor 2
INTERACTION	0.781	
TRUST	0.812	
RESPECT	0.774	
FRIENDSHIP	0.633	
RECIPROCITY	0.828	
COMMON LANGUAGE	0.692	
COMPLEMENTARITY	0.742	
SIMILARITY	0.473	
COMPATIBILITY1	0.678	
COMPATIBILITY2	0.672	
COMMUNICATION		0.515
MEETINGS		0.857
DOCUMENTS		0.662
TRANSMISSION		0.813
TIME		0.803
FLOWS		0.830
RESPONSIBILITY		0.599
APPLICATION		0.678

The results show that the items INTERACTION, TRUST, RESPECT, FRIENDSHIP, RECIPROCITY, COMMON LANGUAGE, COMPLEMENTARITY, SIMILARITY, COMPATIBILITY1 and COMPATIBILITY2 form a single factor, potential absorptive capacity, which is composed of the phases of knowledge acquisition and assimilation. Likewise, items COMMUNICATION, MEETINGS, DOCUMENTS, TRANSMISSION, TIME, FLOWS, RESPONSIBILITY and APPLICATION form a second factor, realized absorptive capacity, which is composed of the phases of transformation and exploitation of knowledge. Loadings greater than 0.30 are considered significant (Hair et al., 1999), such that all the loadings in the study are highly significant.

A confirmatory analysis of the first level was then performed to verify that the four phases and the two dimensions are valid and independent in measuring the final construct. To choose the most appropriate method of estimation. The PRELIS processor was used to analyze the characteristics of multivariate normality through the Multivariate Normality Test for Continuous Variables, presented in Table 6.

The results show the absence of normality in the data. Several statistical methods for structural equation modeling—such as the Maximum Likelihood (ML), Generalized Least Squares (GLs) and Full Information Maximum Likelihood (FIML) methods for standard and multilevel structural equation modeling—assume that the data follow a multivariate normal distribution. In practice, however, as occurs in this study, the assumption of a multivariate Normal data distribution often does not hold. Consequently, alternative methods such as Weighted Least Squares (WLS) are recommended to fit structural equation models to these data sets (Hair et al., 1999). The final method used to estimate the parameters was thus that of weighted least squares (WLS) with the statistical program LISREL 8.30.

Each item was first loaded on the factor for which it had been proposed as an indicator according to the prior exploratory factor analysis, considering the four phases of absorptive capacity (acquisition, assimilation, transformation and exploitation). The process was then repeated, this time considering only two dimensions (potential and realized). The results obtained are shown in Tables 7 and 8, respectively.

The data show that all of the items considered in the final scale have very high factor loadings. All cases are above the recommended level of 0.4 and are also statistically significant, their t-values being higher than the critical value ($t > 1.96$; $\alpha = 0.05$). Further, individual reliabilities exceed the value 0.5. To achieve this, the individual indicators that did not fulfill these conditions were eliminated one by one, re-estimating the model with the elimination of each item. This procedure resulted in the elimination of the items FRIENDSHIP, SIMILARITY and COMMUNICATION.

To complete the analysis, the study examined the measurements of global fit using measures of absolute fit, incremental fit, and parsimonious fit. Tables 9 and 10 summarize these measurements.

With respect to measures of absolute fit, the study must take into account that the basic indicator is the non-significance of the statistical ratio of verisimilitude, which is distributed according to a Chi-square. This statistic assumes the null hypothesis that the matrices observed and estimated are not significantly different. When working with large sample sizes, as is the case in this study, this statistic is always significant ($\chi^2 = 129.83$; 84 degrees of freedom $\chi^2 = 184.64$; 89 degrees of freedom for the final scales

Table 6
Multivariate normality test for continuous variables.

Asymmetry		Kurtosis		Asymmetry and Kurtosis	
z-Score	p-Value	z-Score	p-Value	Chi-square	p-Value
17.695	0.000	9.988	0.000	412.858	0.000

Table 7
Individual validity and reliability of the items in the four phases.

Items		Initial scale			Final scale		
		Loadings (λ)	t-Values	Individual reliability	Loadings (λ)	t-Values	Individual reliability
INTERACTION		0.90	36.98	0.81	0.88	34.65	0.78
TRUST		0.96	59.80	0.93	0.95	55.20	0.90
RESPECT	Acquisition	0.93	42.63	0.87	0.90	36.81	0.81
FRIENDSHIP		0.70	15.55	0.48		Eliminated	
RECIPROCITY		0.95	46.23	0.89	0.92	39.67	0.85
COMMON LANGUAGE		0.87	27.84	0.76	0.84	24.71	0.71
COMPLEMENTARITY		0.94	37.94	0.88	0.91	33.72	0.83
SIMILARITY	Assimilation	0.69	15.08	0.47		Eliminated	
COMPATIBILITY1		0.94	44.14	0.89	0.94	41.20	0.88
COMPATIBILITY2		0.93	42.59	0.86	0.92	39.46	0.84
COMMUNICATION	Transformation	0.63	12.18	0.39		Eliminated	
MEETINGS		0.94	48.08	0.89	0.90	38.12	0.81
DOCUMENTS		0.77	19.79	0.60	0.76	18.27	0.57
TRANSMISSION		0.91	39.21	0.83	0.90	36.63	0.80
TIME		0.92	39.94	0.85	0.91	37.48	0.82
FLOWS		0.92	41.65	0.85	0.91	39.69	0.83
RESPONSIBILITY	Exploitation	0.85	27.05	0.73	0.85	25.66	0.72
APPLICATION		0.97	37.09	0.95	0.95	33.26	0.91

Table 8
Individual validity and reliability of the items of the two dimensions.

Items		Initial scale			Final scale		
		Loadings (λ)	t-Values	Individual reliability	Loadings (λ)	t-Values	Individual reliability
INTERACTION		0.90	38.50	0.81	0.89	36.38	0.79
TRUST		0.97	62.42	0.94	0.96	57.81	0.91
RESPECT		0.94	44.20	0.88	0.91	38.37	0.83
FRIENDSHIP		0.70	16.62	0.49		Eliminated	
RECIPROCITY	Potential	0.95	48.35	0.90	0.92	41.74	0.85
COMMON LANGUAGE		0.88	29.79	0.77	0.85	26.99	0.73
COMPLEMENTARITY		0.94	40.23	0.88	0.91	35.64	0.83
SIMILARITY		0.69	15.76	0.48		Eliminated	
COMPATIBILITY1		0.94	46.62	0.89	0.94	43.80	0.88
COMPATIBILITY2		0.93	44.38	0.86	0.92	41.55	0.85
COMMUNICATION		0.63	13.48	0.40		Eliminated	
MEETINGS		0.94	48.15	0.88	0.90	38.96	0.81
DOCUMENTS		0.77	20.70	0.60	0.76	19.23	0.57
TRANSMISSION	Realized	0.92	41.48	0.85	0.91	39.05	0.82
TIME		0.93	42.34	0.86	0.92	40.26	0.84
FLOWS		0.93	44.00	0.86	0.92	42.37	0.85
RESPONSIBILITY		0.86	30.01	0.74	0.86	29.05	0.74
APPLICATION		0.95	43.55	0.91	0.94	39.08	0.87

of four dimensions and of two dimensions, respectively) (Hair et al., 1999). It is therefore advisable to complement this measurement with others of quality of fit (Bearden et al., 1982; Hair et al., 1999; Marsh et al., 1988). To achieve this, other indicators were analyzed that show less sensitivity to sample size. Among these, the GFI takes values between 0 (poor fit) and 1 (perfect fit). Although there is no limit to affirm that the fit is good (Hair et al., 1999), values higher than 0.90 or 0.95 are recommended (Jöreskog and Sörbom, 1993), higher values representing better fits. For the scales finally proposed, the GFI indicator reaches a value of 0.98 for the scale of four dimensions and 0.97 for the scale of two dimensions, indicating a very good fit in both cases (Hair et al., 1999).

The NCP, SRMR and ECVI indexes are ideal measures of absolute fit for comparing alternate models when the models show a different number of parameters to be estimated and thus a different number of degrees of freedom. In this case, these values are not relevant, as a single scale was presented and thus cannot perform any comparison.

It is also necessary to ensure that the scale presents a good incremental fit. The indicators for this purpose confirm the increase in fit from a base model (normally the null model, which stipulates an absolute lack of association between the variables) and the proposed model. The AGFI, NFI and TLI indexes can take values between 0 (poor fit) and 1 (perfect fit). Although there is no established limit, it is recommended that they take values above 0.9 (Hair et al., 1999; Jöreskog and Sörbom, 1993). In the final scales, all of the indicators are well over the recommended thresholds, for measuring both four dimensions of absorptive capacity (AGFI = 0.97; NFI = 0.97; TLI = 0.99) and two dimensions (AGFI = 0.96; NFI = 0.96; TLI = 0.97). The values obtained by these measures considered jointly ensure the model's incremental goodness of fit.

Table 9
Global fit indexes for the four dimensions.

Absolute measures of fit	Optimal values	Initial scale	Final scale
Degrees of freedom	Highest	129	84
Value of chi-square and significance level	Lowest	180.54	129.83
	$P < 0.01$	0.0019	0.00099
Non-centrality parameter (NCP)	Lowest	51.54	45.83
Goodness of fit index (GFI)	$> 0.9 > 0.95$	0.98	0.98
Standardized root mean square residual (SRMR)	< 0.05	0.21	0.18
Expected cross-validation index (ECVI)	Lowest	1.70	1.29
Incremental measures of fit	Optimal values	Initial scale	Final scale
Adjusted goodness of fit index (AGFI)	$> 0.9 > 0.95$	0.97	0.97
Normal fit index (NFI)	$> 0.9 > 0.95$	0.97	0.97
Tucker–Lewis index (TLI or NNFI)	$> 0.9 > 0.95$	0.99	0.99
Comparative fit index (CFI)	$> 0.9 > 0.95$	0.99	0.99
Incremental fit index (IFI)	$> 0.9 > 0.95$	0.99	0.99
Relative fit index (RFI)	> 0.9 Close to 1	0.96	0.96
Measures of parsimony fit	Optimal values	Initial scale	Final scale
Normed chi-square	> 1 and $< 3 < 5$	1.4	1.55
Parsimony goodness of fit index (PGFI)	Highest	0.74	0.69
Parsimony normed fit index (PNFI)	Highest	0.81	0.78
Akaike Information criterion (AIC)	Lowest	264.54	201.83
Critical *N* (CN)	$> 200 > 75$	147.27	141.66

Table 10
Global fit indexes of the two dimensions.

Measurements of absolute fit	Optimal values	Initial scale	Final scale
Degrees of freedom	Highest	134	89
Value of chi-square and Significance level	Lowest	230.94	184.64
	$P < 0.01$	0.00	0.00
Non-centrality parameter (NCP)	Lowest	96.94	95.64
Goodness of Fit Index (GFI)	$> 0.9 > 0.95$	0.97	0.97
Standardized root mean square residual (SRMR)	< 0.05	0.29	0.27
Expected cross-validation index (ECVI)	Lowest	1.95	1.58
Incremental measures of fit	Optimal values	Initial scale	Final scale
Adjusted goodness of fit index (AGFI)	$> 0.9 > 0.95$	0.96	0.96
Normal fit index (NFI)	$> 0.9 > 0.95$	0.96	0.96
Tucker–Lewis index (TLI or NNFI)	$> 0.9 > 0.95$	0.98	0.97
Comparative fit index (CFI)	$> 0.9 > 0.95$	0.98	0.98
Incremental fit index (IFI)	$> 0.9 > 0.95$	0.98	0.98
Relative fit index (RFI)	> 0.9 Close to 1	0.95	0.95
Measures of parsimony fit	Optimal values	Initial scale	Final scale
Normed chi-square	> 1 and $< 3 < 5$	1.72	2.07
Parsimony goodness of fit index (PGFI)	Highest	0.76	0.72
Parsimony normed fit index (PNFI)	Highest	0.84	0.81
Akaike information criterion (AIC)	Lowest	304.94	246.64
Critical *N* (CN)	$> 200 > 75$	119.21	104.88

Finally, the study must analyze the parsimony of the proposed scale. These measures indicate the level of fit per estimated coefficient, and only the normed Chi-square can be used in the confirmatory analysis. This indicator should take values higher than 1 to ensure that there is no overfit of the data. It must be lower than 3 or even 5 (Hair et al., 1999) to be truly representative of the data. In this case, the value obtained for the scale that measures four dimensions is 1.55 and 2.07 for the scale that measures two dimensions, both cases falling between the strictest lower limit of 1.0 and the upper limit of 3.0 (Hair et al., 1999). The other measurements are only valid for comparison between different alternate scales, which do not fit this case.

In comparing the optimal values with those offered by the measurement instrument, the study confirms that both the absolute measures of fit and the incremental measures of fit, as well as the measures of parsimony of fit, are within the recommended values. Further, the values improve considerably with respect to the initial scale, that is, once the two items that do not fulfill the requirements of individual validity and reliability are eliminated. The same conclusions are obtained when analyzing two dimensions. Based on the discussion above, the scale proposed to measure absorptive capacity fulfils the criteria of convergent validity, both for measuring the phases of acquisition, assimilation, transformation and exploitation of knowledge and for measuring the dimensions of potential and realized absorptive capacity.

4.3. Reliability analysis

Although the previous section treats the individual reliability of the factors, the global reliability of the measurement instrument must ultimately be analyzed. Reliability refers to the internal consistency of the scale and means that the concept has been measured exactly and without incurring errors. Thus, the greater the reliability, the smaller the error and more precise the measurement instrument used (Hair et al., 1999). To analyze global reliability, the study confirms the internal consistency using the Cronbach's Alpha, checking that the latter does not improve if one of the items is eliminated, and ultimately confirming that the values obtained for composite reliability and variance extracted are appropriate.

Table 11
Internal consistency of the final scale for the four Dimensions.

ACQUISITION	Cronbach's alpha: 0. 899		Composite reliability: 0.952 Variance extracted: 0.834	
	Correlation between items	α if this item is eliminated	Standardized load	Standardized errors
INTERACTION	0.767	0.875	0.88 (34.65)	0.22
TRUST	0.835	0.848	0.95 (55.20)	0.099
RESPECT	0.768	0.877	0.90 (36.81)	0.19
RECIPROCITY	0.750	0.879	0.92 (39.67)	0.15
ASSIMILATION	Cronbach's alpha: 0.835		Composite reliability: 0.946 Variance extracted: 0.815	
	Correlation between items	α if this item is eliminated	Standardized load	Standardized errors
COMMON LANGUAGE	0.581	0.828	0.84 (24.71)	0.29
COMPLEMENTARITY	0.666	0.791	0.91 (33.72)	0.17
COMPATIBILITY1	0.706	0.773	0.94 (41.20)	0.12
COMPATIBILITY2	0.711	0.771	0.92 (39.46)	0.16
TRANSFORMATION	Cronbach's alpha: 0.884		Composite reliability: 0.943 Variance extracted: 0.767	
	Correlation between items	α if this item is eliminated	Standardized load	Standardized errors
MEETINGS	0.797	0.840	0.90 (38.12)	0.19
DOCUMENTS	0.605	0.895	0.76 (18.27)	0.43
TRANSMISSION	0.774	0.847	0.90 (36.63)	0.20
TIME	0.728	0.858	0.91 (37.48)	0.18
FLOWS	0.750	0.855	0.91 (39.69)	0.17
EXPLOITATION	Cronbach's alpha: 0.828		Composite reliability: 0.897 Variance extracted: 0.813	
	Correlation between items	α if this item is eliminated	Standardized load	Standardized errors
RESPONSIBILITY	0.712		0.85	0.28
APPLICATION	0.712		0.95	0.093

Table 12
Internal consistency of the final scale for the two dimensions.

POTENTIAL	Cronbach's alpha: 0. 901		Composite reliability: 0.976 Variance extracted: 0.834	
	Correlation between items	α if this item is eliminated	Standardized load	Standardized errors
INTERACTION	0.709	0.886	0.89	0.21
TRUST	0.775	0.880	0.96	0.087
RESPECT	0.708	0.887	0.91	0.17
RECIPROCITY	0.759	0.881	0.92	0.15
COMMON LANGUAGE	0.625	0.894	0.85	0.27
COMPLEMENTARITY	0.687	0.888	0.91	0.17
COMPATIBILITY1	0.627	0.893	0.94	0.12
COMPATIBILITY2	0.617	0.894	0.92	0.15
REALIZED	Cronbach's alpha: 0. 884		Composite reliability: 0.963 Variance extracted: 0.787	
	Correlation between items	α if this item is eliminated	Standardized load	Standardized errors
MEETINGS	0.761	0.855	0.90	0.19
DOCUMENTS	0.570	0.886	0.76	0.43
TRANSMISSION	0.768	0.855	0.91	0.18
TIME	0.741	0.859	0.92	0.16
FLOWS	0.759	0.858	0.92	0.15
RESPONSIBILITY	0.544	0.882	0.86	0.26
APPLICATION	0.630	0.873	0.94	0.13

The Cronbach's Alpha evaluates the rigor with which the indicators measure a concept and confirm what happens to this value if an item is eliminated. It thus confirms whether the property of parsimonious parametrization is fulfilled—whether the scale contains a small number of items carrying relevant and non-redundant information. The indicators of the final scale's internal consistency are shown in Tables 11 and 12.

The closer the Cronbach's alpha value is to 1, the greater the internal consistency of the items that compose the measurement instrument, with values over 0.7 being acceptable results. In this

study, the Cronbach's Alpha of each dimension that composes absorptive capacity easily fulfils this requirement. Further, when an item from each construct is eliminated in the cases where this is possible, the Cronbach's Alpha does not improve in any case except that of eliminating the item DOCUMENTS. However, this improvement is so slight that it does not compensate for the loss of information.

Further, the values obtained for the composite reliability and extracted variance of each construct are above the acceptable limits in all cases. They are 0.7 for composite reliability and 0.5 for variance extracted. The conclusions are the same when analyzing the scale for four and for two dimensions.

5. Conclusions

The alternative measurement that this paper proposes offers a very good fit for measuring absorptive capacity. The proposed scale has demonstrated its value for measuring firms' abilities to acquire, assimilate, transform and exploit knowledge, as well as the dimensions of organizations' potential and realized absorptive capacity. All factors show that the proposed scale for absorptive capacity constitutes a valid and reliable measurement, making it appropriate for use in the scientific community in future empirical research. The results of this study follow those obtained by Zahra and George (2002) and Jansen et al. (2005), which indicate that absorptive capacity in Spanish firms is a process composed of four phases (acquisition, assimilation, transformation and exploitation of knowledge) that can be grouped into two dimensions (potential and realized). The new measurement instrument was constructed and validated following the most frequent recommendations in the scientific literature on the development of scales in the social sciences.

From the foregoing, it can be concluded that the theoretical and practical contribution of this paper is important. From a theoretical perspective, the paper reduces the problem of measuring and identifying the dimensions that shape absorptive capacity. It also provides an exhaustive analysis of the prior scientific literature and guarantees a rigorous empirical validation providing methodological guarantees.

From a practical point of view, this instrument develops empirical research much needed in the academic community that includes some or all of the dimensions of absorptive capacity. Using the proposed instrument, researchers will be able to measure the phases of acquisition, assimilation, transformation and exploitation as well as the dimensions potential and realized.

On the other hand, organizations need such an instrument to identify the abilities they possess, especially those useful for absorbing knowledge from the outside. Firm managers will be able to use the measurement instrument proposed for evaluating the absorptive capacity of their firms and should be aware that firms that focus their efforts on acquiring and assimilating new external knowledge are doing so in the capacity of potential absorption. These firms are thus capable of continually renewing their knowledge stock but should not forget that they can incur the costs of acquisition without obtaining the benefits of exploitation if they do not develop their abilities for transformation and exploitation of knowledge. Firms that focus on transformation and exploitation do so in the capacity of realized absorption. They can achieve short-term benefits through exploitation but may fall into a competitive trap and become unable to respond to changes in the environment if they do not develop their abilities to acquire and assimilate new knowledge (Ahuja and Lampert, 2001). Firms can use the instrument proposed to evaluate those aspects that they must improve to develop specific abilities from their capacities and to ensure that they obtain benefits from the exploitation of the knowledge acquired, while remaining responsive to changes in the environment by renewing and expanding their knowledge bases.

As regards the antecedents of absorptive capacity, organizational mechanisms will affect both dimensions differently. Coordination capacities will primarily improve the potential dimensions, whereas socialization capacities will essentially strengthen the realized dimension (Jansen et al., 2005). This explains why certain organizations (or units) are capable of acquiring and assimilating new knowledge from the exterior and yet are not able to transform or apply it successfully. The solution lies in these organizations' differentiating between their abilities to manipulate the levels of potential and realized absorptive capacity. The measurement instrument proposed facilitates firms' identification of the abilities they must improve.

This research has several limitations that suggest further possibilities for empirical research. First, survey data based on self-reports may be subject to social desirability bias (Podsakoff and Organ, 1986). However assurance of anonymity can reduce such bias even when responses relate to sensitive topics (Konrad and Linnehan, 1995). Second, the cross-sectional nature of the research into a dynamic concept allows analysis of the organizations' situation at only one specific point in time, not their overall conduct over a period of time. Other research recommends using an additional time lag in data collection, but this was not possible due to cost and time constraints. Future research should focus on longitudinal study.

A third potential limitation is the possible bias associated with data collected from a single key informant. Although measures were taken to reduce data inaccuracies, the use of multiple respondents would have been preferable. The use of a single informant is prevalent within management information systems research but always remains a source of bias when interpreting study results (Kearns and Lederer, 2003). Single informants are not uniquely situated to know the personal interpretations of multiple perceivers (Kozlowski and Klein, 2000), and it is unlikely that any one individual can provide a comprehensive view of an entire organization (Klein et al., 2000). It would also be interesting to study similar characteristics with data provided by lower levels of management and employees in the firm.

Fourth, development of a greater collaborative scheme between academics and practitioners could generate an organizational strategy around the concept of absorptive capacity. This would permit further study of the processes, means and mechanisms that can transform absorptive capacity into sustainable competitive advantage. Future studies should be based on larger samples, preferably in more than one country. Fifth, only the chemical and automotive industries were surveyed. Future lines of research must test the measurement instrument in different sectors.

Finally, other future lines of research should be directed to the development and validation of scales that measure other valuable resources and capabilities for organizations, resources and capabilities that explain success in achieving a sustainable competitive advantage over time through assets that are rare, irreplaceable, valuable and difficult to imitate but also difficult to detect and above all to evaluate. Some of the capacities for which alternative measurement instruments could be proposed are flexibility, intra-entrepreneurial capacity, organizational learning, innovation, transformational leadership, and proactivity. Further, empirical papers, especially longitudinal studies, supporting (or rejecting) these results in different contexts about the four stages of absorptive capacity would be welcomed.

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Appendix

Think of that organization—for example, a direct competitor, a firm from another sector or industry, a provider or a client—with which the organization that you manage has had the most frequent contact in the last three years in order to obtain or exchange new information or useful knowledge to develop the organization's activities. Indicate the characteristics of this relationship and of your organization, showing your degree of agreement or disagreement with the following statements:

- Acquisition (Potential)
  1. (INTERACTION) There is close personal interaction between the two organizations.
  2. (TRUST) The relation between the two organizations is characterized by mutual trust.
  3. (RESPECT) The relation between the two organizations is characterized by mutual respect.
  4. (FRIENDSHIP) The relationship with this organization is one of personal friendship.
  5. (RECIPROCITY) The relationship between the two organizations is characterized by a high level of reciprocity.
- Assimilation (Potential)
  1. (COMMON LANGUAGE) The members of the two organizations share their own common language.
  2. (COMPLEMENTARITY) There is high complementarity between the resources and capabilities of the two organizations.
  3. (SIMILARITY) The main capabilities of the two organizations are very similar/overlap.
  4. (COMPATIBILITY1) The organizational cultures of the two organizations are compatible.
  5. (COMPATIBILITY2) The operating and management styles of the two organizations are compatible.
- Transformation (Realized)
  1. (COMMUNICATION) There are many informal conversations in the organization that involve commercial activity.
  2. (MEETINGS) Interdepartmental meetings are organized to discuss the development and tendencies of the organization.
  3. (DOCUMENTS) The different units publish informative documents periodically (reports, bulletins, etc.).
  4. (TRANSMISSION) The important data are transmitted regularly to all units.
  5. (TIME) When something important occurs, all units are informed within a short time.
  6. (FLOWS) The organization has the capabilities or abilities necessary to ensure that knowledge flows within the organization and is shared between the different units.
- Exploitation (Realized)
  1. (RESPONSIBILITY) There is a clear division of functions and responsibilities regarding use of information and knowledge obtained from outside.
  2. (APPLICATION) There are capabilities and abilities needed to exploit the information and knowledge obtained from the outside.

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