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Measurement of knowledge absorptive capacity: An estimated indicator for the manufacturing and service sector in Colombia

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TYPE: Application

Medicion de la capacidad de absorcion: Un indicador estimado para los sectores de manufactura y servicios en Colombia

Medição da capacidade de absorção de conhecimento: Um indicador estimado para o setor manufatureiro e de serviços na Colômbia

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This article proposes an indicator to measure the level of Knowledge Absorptive Capacity in Colombia based on a theoretical review of the concept and different types of empirically validated measurements. We present a definition of Absorptive Capacity and its dimensions, which is validated using the proposed indicator as a linear combination of these dimensions. The estimates have been conducted using the Innovation and Technological Development Survey (EDIT by its initials in Spanish) data for the manufacturing sector and the EDIT for the service sector in Colombia. We conclude that, in general, both sectors have low levels of Absorptive Capacity, with noteworthy exceptions being the chemical products manufacturing, domestic appliances, higher education and research and development center subsectors.

En este artículo se propone un indicador para medir el nivel de capacidad de absorción del conocimiento en Colombia sobre la base de una revisión teórica del concepto y los diferentes tipos de mediciones empíricamente validadas. Se presenta una definición de la capacidad de absorción y sus dimensiones, que se validó mediante el indicador propuesto como una combinación lineal de estas dimensiones. Las estimaciones se han realizado utilizando la Encuesta de Innovación y Desarrollo Tecnológico (EDIT por sus siglas en español) con datos para el sector de manufactura y la EDIT para el sector de servicios en Colombia. Llegamos a la conclusión que en general en ambos sectores existen niveles bajos de capacidad de absorción, con excepciones notables en la manufactura de productos químicos , los electrodomésticos, los subsectors de la educación superior y centros investigación y desarrollo.

Este artigo propõe um indicador para medir o nível da capacidade de absorção do conhecimento na Colômbia, sobre a base de uma revisão teórica do conceito e diferentes tipos de medidas validadas empiricamente. Apresentamos uma definição da capacidade de absorção e as suas dimensões, validada usando o indicador proposto como uma combinação linear destas dimensões. As estimativas levaram-se a cabo mediante os dados obtidos do Inquérito de Desenvolvimento e Inovação Tecnológica (EDIT) para o setor manufatureiro e a EDIT para o setor de serviços na Colômbia. Podemos concluir que, em geral, ambos os setores têm baixos níveis de capacidade de absorção, com exceções notáveis nos subsetores do fabrico de produtos químicos, os eletrodomésticos, a educação superior e os centros de investigação e desenvolvimento.

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1. Introduction

Absorptive Capacity is one of the most important concepts developed in business research over recent years. Introduced by Cohen and Levinthal (1989, 1990), Absorptive Capacity refers to learning processes that are fundamental to the survival of a company in the long term because they complement or readjust company knowledge.

The rapid development of Absorptive Capacity as a research line is, in part, due to its application in various research fields such as strategy formulation, innovation management, cooperation management and organizational learning (Tsai, 2001; Zahra and George, 2002; Camisón and Forés, 2010). The wide range of studies using this concept have proposed important issues relating to Absorptive Capacity, primarily criticizing the fact that no clear definition has been agreed upon (Lane and Lubatkin, 1998). Furthermore, there are also discrepancies in the measurement method; some authors consider it to be a one-dimensional concept while others believe that it is multidimensional.

Upon reviewing research progress in Colombia, empirical evidence was not found within Absorptive Capacity studies, which is a void in the field of knowledge management studies. Due to the importance of this field and given the lack of research in Colombia that would allow these company dynamics to be analyzed, we intend to measure Absorptive Capacity in Colombian companies within two sectors: the Manufacturing sector and the Service sector. To demonstrate this concept, we propose a definition of Knowledge Absorptive Capacity and an indicator to measure this capacity for Colombian companies from these sectors.

This article is divided into the following sections. The first section develops a theoretical framework based on Resources and Capabilities Theory and the Theory of Dynamic Capabilities. We also present the development of the Absorptive Capacity concept as a dynamic capability and the state of research on its measurement form. The second section proposes a methodology to develop a measurement indicator for Absorptive Capacity and empirically validates it. The third section presents results on the level of Absorptive Capacity in the manufacturing and service sectors. Finally, we present conclusions, limitations and future lines of research.

Key words
Absorptive capacity, Innovation, Knowledge, Economic sectors

Palabras clave
Capacidad de absorcion, Innovacion, Conocimiento, Sectores economicos

Palavras-chave
Capacidade de absorção, inovação, conhecimento, setores económicos

2. Literature Review

2.1. Resources and Capabilities Theory

For a company, resources and capabilities are the basis for producing the goods and services that allow it to generate a sustainable competitive advantage. Based on this approach, many authors have analyzed companies by considering their ability to exploit resources and capabilities in response to opportunities presented by the environment and to neutralize external threats that could impact company productivity (Wernerfelt, 1984; Prahalad and Hamel, 1990; Peteraf, 1993). This interest in resources and capabilities as the focus of company strategy reflects the importance of competitiveness and its association with achieving profitability. This same focus gave birth to Resources and Capabilities Theory, initially described by Wernerfelt (1984), Barney

JEL Codes:
O31, M10

(1991), Grant (1991), and Peteraf (1993), which is based on the assumption of heterogeneity in the resources and capabilities of each company, with companies having distinct and superior skills that lead to a competitive advantage in the market.

The Resource and Capabilities Theory states that companies possess distinctive resources and capabilities that are a source of competitive advantage. These resources and capabilities include Absorptive Capacity, which allows the use of knowledge to create an advantage (Wernerfelt, 1984). In this theory, one of the primary resources of a company is tacit knowledge (Grant, 1996). Tacit knowledge is considered to be a strategic resource, and the skill exhibited in obtaining it is a primary capability leading to competitiveness (Cohen and Levinthal, 1990). Within the theoretical developments in the field of the Resource and Capabilities Theory, Absorptive Capacity is part of the Dynamic Capabilities Approach. This approach considers a knowledge absorption process that includes various phases from acquisition and assimilation to transformation and application (Zahra and George, 2002), which in turn leads to creating new organizational capabilities.

2.2. Dynamic Capabilities Theory

The Dynamic Capabilities Theory is derived from the Resource-Based View and Capabilities Theory and was created in the 1990s. This theory follows market dynamics, which indicate that the propositions from Resource and Capabilities Theory be considered static (Eisenhardt and Martin, 2000). Dynamic Capabilities Theory originates a new approach that improves the explanatory capacity of the Resource-Based View and Capabilities Theory by trying to take into account the dynamism of the market in terms of competition and the acquisition of complementary resources.

The Resource and Capabilities Theory was extended to dynamic markets because some researchers felt that this theory had not satisfactorily explained how and why some companies have competitive advantages in situations of rapid and unforeseeable change (Eisenhardt and Martin 2000). In this type of environment, the dynamic capabilities of a company's management become a source of sustained competitive advantage and knowledge becomes a highly critical resource (Grant, 1996).

Dynamic capabilities lead to the formation of strategic organizational routines that allow the alteration of the resource base through acquisition, integration or resource recombination to generate new value-creating strategies (Grant, 1996; Pisano, 1994).

Zollo and Winter (2002) state that dynamic capabilities correspond to a collective activity pattern that generates and modifies routines by seeking greater organizational efficiency. They define three mechanisms that create and develop dynamic capabilities: the accumulation of experience and organizational routines, the articulation of knowledge and the codification of knowledge. The interaction of these mechanisms improves the already existing organizational routines and combine tacit and explicit knowledge by forming social processes that allow for tacit knowledge transmission and promote the creation, acquisition, transfer and integration of knowledge.

The Role of Absorptive Capacity as a dynamic capability is attributed to its knowledge creation function, which is required to develop new organizational capabilities (Zahra and George, 2002; Todorova and Durisin, 2007; Wang and Ahmed, 2007). These capabilities result in innovation development, which allows organizations to adapt to changing surroundings.

2.3. Absorptive Capacity as Dynamic Capability

Some authors describe Absorptive Capacity as an organizational capacity (Cohen and Levinthal, 1990), and others such as Zahra and George (2002) define it as a dynamic capability.

The term 'Absorptive Capacity' was introduced by Cohen and Levinthal (1989) about a company's ability to identify, assimilate, and exploit knowledge from external surroundings. This initial definition belongs to the field of behavioral and learning sciences, and various authors have subsequently redefined the concept along the same lines. The contributions of Lane and Lubatkin (1998) and Dyer and Singh (1998) continue the study of Absorptive Capacity focused on learning, which is consistent with the initial definition (Cohen and Levinthal, 1989; 1990). More recent studies, such as Flatten et al. (2011) and Jiménez-Barrionuevo et al. (2011), have returned to this point of view by addressing how Absorptive Capacity could be better developed by examining the cognitive structures underlying the learning process.

Zahra and George (2002), however, propose a redefinition of Absorptive Capacity, arguing that the theoretical contributions up until now were somewhat ambiguous in their definition, components, and history. These authors define Absorptive Capacity as the set of strategic organizational routines and processes that make it possible for companies to acquire, assimilate, transform and exploit knowledge to create dynamic capabilities. The contribution of Zahra and George (2002) allows us to recognize Absorptive Capacity as a dynamic capability that impacts the sustainability of a company's competitive advantage by making it easier for an organization to adapt administrative action to redefine and develop knowledge-based assets.

Based on this new definition, other authors supported the definition of Absorptive Capacity as a dynamic capability. Minbaeva et al. (2003) note that Absorptive Capacity should be the interactive effect between the recognition, the assimilation and the commercialization of new knowledge, as a high level of performance is required at all these levels. Lane, Koka and Pathak (2006) also propose a new definition of Absorptive Capacity based on their analysis of the concepts proposed by Cohen and Levinthal (1989, 1990), Lane and Lubatkin (1998) and Zahra and George (2002). They suggest that Absorptive Capacity allows a company to search for knowledge that can help to satisfy specific needs; they also analyze this phenomenon as the result of past innovation and the company's problem-solving capabilities (Lane, Koka and Pathak, 2006).

The definition of Absorptive Capacity as a dynamic capability implies that it is a construct comprised of various dimensions. There is no consensus on the number of dimensions, but the most common include identification, acquisition, assimilation, exploitation, application, transformation, etc., according to the approach of each author. Table 1 shows the dimensions considered by different authors:

Table 1. Dimensions of Absorptive Capacity

AUTHORS	DIMENSIONS
Cohen and Levinthal (1989), Cohen and Levinthal (1990), Mowery and Oxley (1995) Cockburn and Henderson (1998), Szulanski (1996), Chen et al. (2014), Chang et al. (2014), García-Morales et al. (2014)	Identification Assimilation Exploitation
Heeley (1997)	Acquisition Diffusion Technical Capabilities
Lane and Lubatkin (1998), Dyer and Singh (1998), Minbaeva et al. (2003), Lane, Koka and Pathak (2006), Schildt et al. (2012)	Recognition / Valuation Assimilation Application
Zahra and George (2002), Jansen et al. (2005) Vega-Jurado et al. (2008) Gluch et al. (2009), Flatten et al. (2011), Jiménez-Barrionuevo et al. (2011), Datta (2011), Ritala and Hurmelinna (2013), Waranantakul and Ussahawanitchakit (2012) Maynez-Guaderrama et al. (2012) Gebauer et al. (2012) Cepeda-Carrión et al. (2012), Su et al. (2013), Patterson y Ambrosini (2015), Lao y Lu (2015)	Acquisition Assimilation Transformation Exploitation
Todorova and Durisin (2007)	Recognition Acquisition Assimilation Transformation Exploitation
Murovec and Prodan (2009)	Scientific Absorptive Capacity Market Absorptive Capacity
Liao et al. (2010)	Assessment Use
Xiong and Bharadwaj (2011)	Knowledge Absorptive Capacity in R&D Knowledge Absorptive Capacity in marketing Client knowledge Absorptive Capacity
Hadi et al. (2011)	Complementarity Prior knowledge Related experience
Nugraha (2011)	Potential: organization mechanisms, human resource practices, knowledge attributes Realized: Employee performance

Source: Author's elaboration.

2.4. Absorptive Capacity and its Measurement

Absorptive Capacity is a variable frequently used in research on R&D (Cohen and Levinthal, 1989, 1990; Lane and Lubatkin, 1998; Dyer and Singh, 1998; Flatten et al., 2011; Jiménez-Barrionuevo et al., 2011, Dinar, 2014, among others), innovation (Mowery and Oxley, 1995; Gluch et al., 2009; Murovec and Prodan, 2009; Liao et al., 2010; Ritala and Hurmelinna, 2013, Egbetokun y Savin, 2014; Wang et al., 2014, among others), networks (Xiong and Bharadwaj, 2011; Robertson et al., 2012; Schildt et al., 2012, Ahlin et al., 2014) and performance (Park y Rhee, 2012; Kauppi et al., 2013; Sciascia et al., 2014; Martins, 2014, Wu y Voss, 2015). In these areas of research, the focus is on establishing the activities that lead an organization to acquire and exploit knowledge developed by others. The use of the Absorptive Capacity concept in different fields reflects its multidisciplinary appeal but also makes it difficult to establish unified criteria for its conceptualization and measurement. While some authors measure Absorptive Capacity using tangible resources, others use intangible assets, which are difficult to evaluate and measure (Itami, 1987).

Therefore, identifying a measure of Absorptive Capacity that would bring together its primary characteristics requires an analysis of the measures used in prior research. Empirical studies on the subject present different forms of measurement for Absorptive Capacity: some take into account the described dimensions while other use specific indicators.

Tables 2 and 3 show the different measurement methods used in prior empirical studies according to the type of measurement; these use quantitative indicators or scales based on the dimensions of Absorptive Capacity.

The study of these different types of measurement allows us to create a list of the most representative indicators, taking into account the resources and capabilities of the company in these measurement forms. Some studies measure Absorptive Capacity as a multidimensional construct, trying to measure each of the dimensions described above; others treat it as a one-dimensional construct and use specific quantitative indicators.

Table 2 summarizes the primary quantitative indicators used to measure Absorptive Capacity, cataloged according to measurement reference. The number of units, percentages, ratios, weights, etc. characterizes these quantitative variables.

Among the Absorptive Capacity indicators, those that are the most used in the literature are classified in the first category; these use measures related to research and development (R&D) and the innovative activities of a company. According to Cohen and Levinthal (1990), Absorptive Capacity is a byproduct of R&D and allows for an understanding of the impact of learning on R&D expenditure; to gain this understanding, R&D intensity is used as a measure of Absorptive Capacity, defined as the expenditure on R&D divided by sales.

The second category includes the individual characteristics of the company; type of staff hired, staff skills, and management abilities are the most important (Escribano et al., 2009; Kostopoulos et al., 2011; Luo, 1997; Castellacci y Najera, 2013).

The third category of indicators is comprised of scientific output measures. Knowledge participation is measured as the percentage of research communities associated with a scientific field, including the number of publications within a scientific community (Cockburn and Henderson, 1998; Mangematin and Nesta, 1999).

The fourth category of Absorptive Capacity quantitative measures includes variables that measure participation in company networks or alliances. Mangematin and Nesta (1999) find that companies have close links to scholars and measure this variable using event participation. Vega-Jurado et al. (2008) use the number of R&D alliance members to capture external knowledge.

The fifth category includes the variables measuring Absorptive Capacity through the organizational structure. Minbaeva et al. (2003) uses dichotomous variables that measure the presence of human resources management practices and employee ability as measured by performance assessment.

The last category measures Absorptive Capacity by studying the environmental conditions. Xiong and Bharadwaj (2011) measure Absorptive Capacity in marketing through the amount of marketing knowledge absorbed as reflected in the number of brands held by a company and through market conditions as measured by dummies based on sector type (according to the industrial classification coding).

Table 2. Quantitative Indicators of Absorptive Capacity

Autores	R&D						Individual characteristics		Scientific Production	
	R&D Intensity	R&D Investment	Technological information	R&D dept staff	R&D Dept/activities	Machinery and expenditure technology	Technical and professional staff	Staff training	Number of scientific publications	Number of patents/registered trademarks
Becker y Peters (2000)					x					
Boynton et al. (1994)			x							
Cohen and Levinthal (1990)	x									
Cockburn and Henderson (1998)									x	
Escribano et al. (2009)		x		x		x	x	x		
George et al. (2001)		x								x
Keller (1996)							x			
Kostopoulos et al. (2011)		x			x		x	x		
Liu and White (1997)		x								
Luo (1997)							x			
Mangematin and Nesta (1999)		x		x	x				x	x
Minbaeva et al. (2003)										
Mowery and Oxley (1995)		x								
Petroni and Panciroli (2002)	x							x		
Poldahl (2012)		x								
Schildt et al. (2012)		x								x
Van de Bosch et al. (1999)										
Vega-Jurado et al. (2008)						x				
Veugelers (1997)				x	x					
Xiong and Bharadwaj (2011)		x								x
Castellaci and Najera (2013)							X	X		
Montinaria and Rochlitz (2014)			x			x				

Continued...

Table 2. Quantitative Indicators of Absorptive Capacity (continued)

Autores	Networks			Organizational Structure				Surroundings
	Number of partners/affiliates	Alliances with research institutes	Use of scientific jorunals/attending events	Use of manuals/ policies	Human resources practices	organizational forms	Incentive systems	Market conditions
Becker y Peters (2000)								
Boynton et al. (1994)								
Cohen and Levinthal (1990)								
Cockburn and Henderson (1998)								
Escribano et al. (2009)								
George et al. (2001)								
Keller (1996)								
Kostopoulos et al. (2011)								
Liu and White (1997)								
Luo (1997)								
Mangematin and Nesta (1999)		x	x					
Minbaeva et al. (2003)					x	x		
Mowery and Oxley (1995)								
Petroni and Panciroli (2002)								
Poldahl (2012)								
Schildt et al. (2012)								
Van de Bosch et al. (1999)							x	
Vega-Jurado et al. (2008)		x	x					
Veugelers (1997)								
Xiong and Bharadwaj (2011)	x							x
Castellaci and Najera (2013)								
Montinaria and Rochlitz (2014)								

Source: Author's elaboration.

However, Absorptive Capacity has also been measured using Likert scales based on diverse categories (Table 2), the majority of which focus on describing each of the dimensions of Absorptive Capacity according to the concept proposed by the particular author. Some authors focus their scale on analyzing the internal capabilities of companies in knowledge absorption (Szulanski, 1996; Chen, 2004; Warajajtakul and Ussahawanitchakit, 2012; Maynez-Guaderrama et al., 2012; Lane and Lubatkin, 1198; Gluch et al., 2009; Gebauer et al., 2012; Ritala and Huermelinna, 2013). Other authors focus on external knowledge sources (Heeley et al., 1997; Murovec and Prodan, 2009; Bogers and Lhuillery, 2011; Jimenez-Barrionuevo et al., 2011; Flatten et al., 2011). There are also authors who construct the scale using two criteria: internal capabilities and external sources (Jansen et al., 2005; Nieto and Quevedo, 2005; Flor et al., 2011; Cepeda-Carrion et al., 2012; Liao et al., 2012; Engelen et al., 2014; Popaitoon and Siengthai, 2014; Seo et al., 2015).

Table 3. Measurement of Absorptive Capacity using Likert Scales

SCALE MEASUREMENTS		
Authors	Number of items	Reference theme
Szulanski (1996)	9 item Scale	Internal capacities
Heeley (1997)	24 item Scale	Acquisition and dissemination of new knowledge
Lane y Lubatkin (1998)	17 item Scale	Organizational management capacities (R&D decisions, management decisions, formalization and centralization
Chen (2004)	5 items Scale	Internal capacities
Jansen et al. (2005)	21 item Scale	Szulanski's (1996) scale and Market Orientation Scale (Jaworski and Kohl, 1993)
Nieto and Quevedo (2005)	36 item Scale	Company-environment relationship, company knowledge and experience level, knowledge structure diversity, strategic posture
Gluch et al. (2009)	10 item Scale	Routines for acquiring and assimilating knowledge
Murovec and Prodan (2009)	6 item Scale	External knowledge sources
Bogers and Lhuillery (2011)	5 item Scale	External knowledge sources
Nugraha (2011)	5 item Scale	Employee performance
Flor et al. (2011)	18 item Scale	Dimensiones de Zahra y George (2002)
Jimenez-Barrionuevo et al. (2011)	18 item Scale	Relations with external knowledge sources
Flatten et al. (2011)	14 item Scale	External knowledge sources
Cepeda-Carrion et al. (2012)	21 item Scale	Janse et al.'s (2005) scale
Warajajtakul and Ussahawanitchakit (2012)	12 item Scale	Internal capacities
Gebauer et al. (2012)	32 item Scale	Learning processes for knowledge acquisition
Liao et al. (2012)	36 item Scale	Nieto and Quevedo's (2005) scale
Maynez-Guaderrama et al. (2012)	6 item Scale	Individual employee capacities
Ritala y Hurmelinna (2013)	4 item Scale	Information acquisition
Seo et al. (2015)	4 item Scale	Individual absorptive capacity
Engelen et al. (2014)	20 item Scale	Jansen et al (2005)
Ahlin et al. (2014)	9 item Scale	Realized absorptive capacity
Ferreras-Méndez (2015)	18 item Scale	Internal and external capacities
Popaitoon and Siengthai (2014)	18 item Scale	Jansen et al (2005)
Leal-Rodriguez et al. (2014)	21 item Scale	Jansen et al (2005) and Cepeda-Carrion et al. (2012)

Source: Author's elaboration.

3. Methodology

The present research work is based on a theoretical review of the concept of Absorptive Capacity and the empirical evidence in there; its aim is to construct a measurement indicator for Absorptive Capacity. To conduct these estimates, we use a database created by the Department of National Administrative Statistics (DANE, using its initials in Spanish), which is the body responsible for gathering statistical data in Colombia. This database was created from the Technological Development and Innovation Survey EDIT V, conducted for the manufacturing sector in Colombia for the 2009-2010 period, and from EDITS II and EDITS III, conducted for the service sector in Colombia for the 2008-2009 and 2010-2011 periods, respectively. The 2009-2010 period was used for both sectors. The EDITS III survey was applied to 5,423 companies from the service sector in 2011, from which 5,038 companies provided information. The EDIT V survey was applied to 9,396 companies in the manufacturing sector identified from the Annual Manufacturing Survey Directory, EAM 2010, of which 8,643 companies provided information.

This survey is a census type conducted by DANE; the target population is industrial and service sector companies with 10 or more employees or with annual production over $130.5 million pesos for 2008. The EDIT survey was conducted according to the methodological guidelines established by the Organization of Economic Cooperation and Development (OECD), specifically the Oslo manual, and by the Ibero-American Network of Science and Technology Indicators (RICYT) in the Bogota Manual.

The validation stages conducted are as follows:

Content validity: to establish the relevance of the content for the analysis of the construct, a dimensionality assessment should be conducted to guarantee the inclusion of phases comprising the construct and discarding specification errors of the measurement instrument (MacKenzie et al., 2005). Validity assures the existence of a relationship between the indicators and the construct, guaranteeing the reliability of the measures (Hair et al., 1999) and assuring that the items included in the measurement instrument address not only the empirical aspects but also the theoretical and practical aspects of the concept to be measured (Churchill, 1979).

Construct validity: performed by estimating an exploratory factor analysis, which empirically validates whether the selected indicators in the content specification group are included in the same factor or construct. The obtained factors are latent constructs or variables, which are subtracted from the correlations between the indicators (Nunally, 1978), allowing us to prove that the defined concept is being measured. A validation should be performed verifying the reliability of the obtained factors (using Cronbach's Alpha) and the correlation between variables of the same factor (Pearson Correlation).

Specifying the indicators: in this stage, we validate the construct obtained in the factor analysis, analyzing the existing relationship between the indicators and the construct (MacKenzie et al., 2005). We verify the reliability dimensions of the construct and its indicators using the following tools.

Cronbach's Alpha: this coefficient allows us to validate the internal consistency of a construct by estimating the reliability of the measurement instrument and assessing whether the set of items measuring one theoretical dimension is highly correlated (Cronbach, 1951). Various authors provide values that the coefficient should achieve to be considered valid; in this study, we consider the criterion given by Nunnally (1978), who states that in an empirical research project, the reliability value should be over 0.7.

Pearson Correlation Coefficient: this is a statistical index measuring the linear relationship between two quantitative variables. The purpose of this coefficient is to establish whether there is a correlation between two variables (Pearson, 1986).

In the content validity verification, we also use these two tools before starting the factor analysis. These tools validate and start to filter the variables that will not be part of each construct. A subsequent factor analysis to validate the final construct was also performed.

Indicator calculation: After validating the construct, a formula is proposed to validate the Absorptive Capacity indicator, based on the methodology used by Sullivan (1994) and adjusted by Ramaswamy et al. (1996) to estimate an indicator for the degree of company internationalization.

Sullivan (1994) starts with a total-item analysis method for constructing homogenous measures developed by Nunnally (1978), who points to the superiority of linear models because they avoid specific measurement problems and who highlights the internal consistency of estimating a construct through a linear combination of individual measures. This technique relates each element of the indicator with the score of each variable; the indicator is defined as the sum of the scores of all of its constituent elements. This method is carried out after identifying a set of measures that have a high Cronbach's alpha coefficient and estimating the Factor Analysis, which locates the elements in just one factor.

For each dimension, a ratio is estimated that varies in the 0-1 range and indicates the percentage for the presence of this dimension in the Absorptive Capacity of the sample companies. Once this estimation is completed, we estimate the total indicator as a linear combination, summing the obtained value by dimension and establishing categories or value ranges to measure the level of Absorptive Capacity.

The Re-Scaling Model described by Schuschny and Soto (2009) is used to standardize the indicator, which transforms variable levels and fits them into the [0,1] interval, estimating the difference between the minimum and the maximum value of the variable in its set. This data standardization method allows for easier understanding of the different measurement units and avoids information bias errors in the data.

Additionally, to establish an analysis scale for the Absorptive Capacity level based on Schuschny and Soto (2009), we transform the scale into a percentage indicator, which allows comparisons between sectors.

4 Results

4.1. Content Validity

Starting from the theoretical review of the different concepts of Absorptive Capacity and its different dimensions, we propose the following definition of Absorptive Capacity:

> Knowledge Absorptive Capacity is the dynamic capability of companies to acquire, assimilate, transform and apply external knowledge to develop innovation processes. This capacity is based on the existence of prior knowledge that is completely assimilated and spread between various members of the organization; this prior knowledge is also integrated with newly acquired knowledge in the development or modification of skills and routines that promote the innovation process.

This definition has been developed based on the propositions of Cohen and Levinthal (1990), Heeley (1997), Lane and Lubatkin (1998), and Zahra and George (2002). We consider Absorptive Capacity to be a dynamic capability, as established by Zahra and George (2002); this takes into account that knowledge accumulation in a company can vary according to the environmental conditions. These conditions can lead to processes of knowledge acquisition that are agile and productive; contrarily, they can also slow processes, making them difficult to adapt to the conditions of the company.

According to the proposed definition, we put forward four dimensions of Absorptive Capacity, which are considered to be stages of capacity accumulation: Acquisition, Assimilation, Transformation and Exploitation.

• Acquisition: the capacity of a company to capture external knowledge based on its efforts to acquire it (Cohen and Levinthal, 1990). According to Lane and Lubatkin (1998), the acquisition of knowledge will depend on the type of knowledge to be acquired and its similarity to existing knowledge and practices. This phase is measured using three items based on the Flor et al. (2011) scale, which captures the intensity and speed in acquiring new knowledge:

X_1 = R&D investment (in thousands of pesos).
X_2 = Technology Transfer Investment (in thousands of pesos).
X_3 = Investment in Machinery and Equipment (in thousands of pesos).

• Assimilation: the internalization and diffusion of acquired external knowledge (Lane and Lubatkin, 1998). This process is focused on the employees of the organization who, through their own abilities and routines, should correctly process the new knowledge and relate it to existing knowledge. Assimilation is based on existing relationships with external agents (Cohen and Levinthal, 1990). The items used are based on the Nieto and Quevedo (2005) and Flor et al. (2011) scales, which measure the capacity for analyzing and understanding new knowledge through routines that relate shared knowledge with individual knowledge:

X_4 = Supplier Cooperation (number of companies that cooperate with suppliers).
X_5 = Institutional Cooperation (number of companies that cooperate with Institutes).
X_6 = Client Cooperation (number of companies that cooperate with clients).

• Transformation: the construction of new routines, leading to the development of new products and/or processes once the new knowledge is assimilated and spread throughout the organization. Based on Zahra and George (2002), transformation includes the ability of the company to reform its organizational routines with the aim of achieving subsequent knowledge application. The Jansen et al. (2005) and Jiménez-Barrionuevo et al. (2011) scales, which use items related to the registration and storage of documents for future consultation, are adapted for this concept along with Flor et al. (2011), which measures the fulfillment of training courses, patent acquisition, the use of consulting services, scientific and technical publications. Therefore, the variables selected are the following:

X_7 = Staff involved in TIA (number of employees participating in technology and innovation activities).
X_8 = Education and Training (number of companies that have established support relationships with consulting firms).
X_9 = Support in technical assistance and consulting (number of employees trained and/or educated by the companies).

• Exploitation: given the capacity to acquire, assimilate, diffuse and transform external knowledge, the company should continue with the process of applying this knowledge; according to Lane and Lubatkin (1998), this step can be seen as achieving the company goals and satisfying its needs. This application is reflected in improving existing competences, generating new competence sets, or creating new products or processes (Cohen and Levinthal, 1990). This dimension is measured by the Gebauer et al. (2012) scale, which uses commercial applications of the acquired knowledge, together with the Flor et al. (2011) scale, which measures activities related to product or process changes and improvements:

X_{10} = Innovation in production methods (measured by the number of innovations of this type implemented by companies).
X_{11} = Improvement in the quality of products and/or services (measured by the number of important innovations of this type implemented by companies).
X_{12} = Broadening the range of products and/or services (measured by the number of important innovations of this type implemented by companies).

In this research project, Absorptive Capacity is interpreted as a multidimensional construct with various dimensions, which have their own measures or indicators (Podsakoff et al., 2006). Additionally, each of these dimensions is different, but they are all related to each other (Law et al., 1998). Thus, eliminating any of the dimensions could alter the conceptual dominion of the construct.

4.2. Construct Validity

We conduct exploratory factor analysis for both samples. Initially, we analyze the results of the KMO coefficient and Bartlett's sphericity test. The former determines whether the partial correlations between variables are too small; for values below 0.5, the use of factor analysis is invalidated for the data (Hair et al., 1999). Bartlett's sphericity test assesses the null hypothesis that the correlation matrix is an identity matrix, in which case there would be no significant correlations between variables and factor analysis would not be appropriate (Hair et al., 1999); the null hypothesis is rejected for a significance level below 0.05 in the Chi-squared statistic.

As shown in Table 4, a KMO coefficient equal to 0.764 and a Chi-squared significance level below 0.05 are obtained for the manufacturing sector sample, thus confirming the relevance of the factor analysis. For the service sector, we find a KMO coefficient below 0.5, but the hypothesis of the correlation matrix as an identity matrix is rejected; thus we consider the process to be appropriate for the sample.

Table 4. KMO and Bartlett's Test

		Manufacturing	Services
Kaiser-Meyer-Olkin sample adjustment measure		0.764	0.439
Bartlett's sphericity test	Approximate Chi-squared	759.798	355.215
	gl	105	105
	Sig.	0.000	0.000

Source: Author's elaboration.

Before conducting the factor analysis, we estimated Cronbach's Alpha and the bivariate correlation between the constructs. The former provides a preliminary analysis of the proposed constructs to verify whether they are valid as has been proposed.

We find the same results for both the estimates of Cronbach's Alpha and the Pearson Correlation coefficient for the initial constructs:

- In the Acquisition phase, the variable X_3 (Investment in machinery and equipment) does not have a significant correlation with the other variables from the construct, leading to its elimination for the purposes of estimation.
- In the Assimilation phase, there is a significant correlation between all cooperation variables.
- In the Transformation phase, the variable X_9 (Support in counseling and consulting) does not have a significant correlation with the other variables, leading to its elimination from the construct.
- In the Exploitation phase, the variable X_{10} (Innovation in production methods) does not have a significant correlation with the other variables, leading to its elimination from the construct.

Based on these results, we conduct exploratory factor analysis excluding the variables that we have mentioned (X_3, X_9, X_{10}). For the manufacturing sector, we obtain a KMO of 0.768, and 86% of the variance explained by the model; in the service sector, we obtained a KMO of 0.687 and 93% of the variance explained by the model. These results allow us to validate the scope of the analysis because they allow us to consider that the resulting factors explain a high percentage of the Absorptive Capacity concept's variance. Table 5 shows the factors obtained and their corresponding factorial weight for the constituent variables, confirming that Absorptive Capacity in Colombia coincides with the four dimensions postulated for this research project.

The factorial weights obtained for each variable are greater than 0.5, which guarantees that they belong to the factor in which they are classified.

Table 5. Exploratory Factor Analysis

MANUFACTURING SECTOR				
	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
X1	0.900			
X2	0.933			
X4		0.907		
X5		0.807		
X6		0.947		
X7			0.934	
X9			0.835	
X11				0.566
X12				0.727
SERVICE SECTOR				
	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
X1	0.838			
X2	0.690			
X4		0.674		
X5		0.964		
X6		0.941		
X7			0.584	
X8			0.784	
X11				0.833
X12				0.813

Source: Author's elaboration.

4.3. Specification of Indicators

With the results obtained from the factor analysis, we should verify again that these indicators cover the entire scope of the latent variable, as described in the content specification (Diamantopolous and Winklhofer, 2001). In other words, the selected indicators should capture Acquisition, Assimilation, Transformation, and Exploitation; to verify this, we validate the reliability of the new constructs using Cronbach's Alpha and the Pearson Correlation coefficients.

Table 6 shows the Cronbach's Alpha coefficient for each construct, finding that all scales oscillate around 0.7 and that various scales do indeed exceed this value, meeting the reliability criterion of the Nunnally Scale (1978).

Table 6. Reliability in the Measurement of the Absorptive Capacity Construct Dimensions

MANUFACTURING SECTOR											
ACQUISITION			ASSIMILATION			TRANSFORMATION			EXPLOITATION		
Cronbach's Alpha = 0.784			Cronbach's Alpha = 0,913			Cronbach's Alpha = 0,754			Cronbach's Alpha = 0,677		
Variable	Correlation Item	Alpha does eliminate item	Variable	Correlation Item	Alpha does eliminate	Variable	Correlation Item	Alpha does eliminate item	Variable	Correlation Item	Alpha does eliminate item
X1	0.741		X4	0.905		X7	0.801		X11	0.713	
X2	0.741		X5	0.841		X8	0.801		X12	0.713	
			X6	0.878							
SERVICE SECTOR											
ACQUISITION			ASSIMILATION			TRANSFORMATION			EXPLOITATION		
Cronbach's Alpha = 0.768			Cronbach's Alpha = 0.696			Cronbach's Alpha = 0.755			Cronbach's Alpha = 0.763		
Variable	Correlation Item	Alpha does eliminate item	Variable	Correlation Item	Alpha does eliminate	Variable	Correlation Item	Alpha does eliminate item	Variable	Correlation Item	Alpha does eliminate item
X1	0.697		X4	0.598		X9	0.805		X14	0.828	
X2	0.697		X5	0.711		X11	0.805		X15	0.828	
			X6	0.699							

Source: Author's elaboration.

The Pearson correlations between the variables of each construct exceed 0.5, and these correlations have been found to be significant. We confirm the validity of measuring Absorptive Capacity in the manufacturing and services sector in Colombia using the presented variables; also, we note that these variables include the primary components analyzed in the prior research.

4.4. Calculation of the Indicator

According to the proposition of Sullivan (1994) and Ramaswamy et al. (1996) for the structuring of an aggregate indicator, we propose an indicator of the Absorptive Capacity level that integrates various variables and moves beyond one-dimensional measures. This type of indicator justifies the use of a multi-element scale that can take advantage of greater valid content variety to construct the index; this reflects a more solid methodological practice that uses the selection of theoretically validated indicators, which justifies their adhesion (Ramaswamy et al., 1996).

A variable aggregation method should be implemented, for example, a sum, a weighted arithmetical mean, a weighted geometrical average, multi-criteria approximation, among others. In this study, we propose using an indicator based on the arithmetical mean as an aggregation method:

CAPAB= ADQ + ASIM + TRANS + EXPLOiT

Where
ADQ = measures the degree of knowledge acquisition by summing R&D investment and technology transfer as a percentage of total TIA.
ASIM = measures the degree of knowledge assimilation by summing each type of cooperation as a percentage of the total number of companies that have cooperated with other partners.
TRANS = measures the degree of knowledge transformation by summing the variables regarding staff involved in TIA with education and training as a percentage of the total number of company employees.
EXPLOIT = measures the degree of knowledge exploitation by summing the variables regarding the creation of new products and the improvement of existing products as a percentage of the total number of innovations implemented by the company.
In the present study, the standardization of the resulting variables for each dimension is performed using the re-scaling conducted by Schuschny and Soto (2009), which additionally allows variables to be normalized with different measurement methods. The standardization formula is the following:

$$(1)\ Y_i = \frac{X_i - min \sum X}{\max \sum X - \min \sum X}$$

Where
Yi = Standardized variable
Xi = Variable to be standardized
min $\sum X$ = Minimum value of variable X
max $\sum X$ = Maximum value of variable X

In summary, the aggregate indicator captures the four dimensions of Absorptive Capacity, which have been theoretically defined and validated by factor analysis. Based on the standardization performed, the indicator scale ranges between 0 and 4, where 0 implies a null level of Absorptive Capacity and 4 implies the maximum level of Absorptive Capacity. However, to allow comparisons, we opt for the use of percentage indicators through the following formula:

(2) Indicator % = (CAPABi– MINscale)/ MAXscale

Where
CAPABi = Absorptive Capacity result by each subsector
MINscale= Minimum value of the obtained scale (0)
MAXscale = Maximum value of the obtained scale (4)

4.5. Results for the level of Absorptive Capacity in the Colombian Manufacturing Sector

Table 8 shows the obtained results for the level of Absorptive Capacity for each of the manufacturing subsectors.

Table 8. Level of Absorptive Capacity in the Manufacturing Sector

ISIC	Subsector name	CAPAB	%
151	Production, processing and preservation of meat and fish	1,03	26%
152	Production of oils and fats, processing of fruit and vegetables	1,39	35%
153	Production of dairy products	1,53	38%
154	prepared food for animals	1,39	35%
155	Production of bakery goods, pastas, noodles, couscous and similar products	0,99	25%
156	Production of coffee goods	1,92	48%
157	Sugar mills and refineries	1,3	33%
158	Production of other food	1,36	34%
159	Production of drinks	1,18	30%
171-172	Preparation and sewing of textile fibers/knitting textile products	2,14	54%
173	Preparation and sewing of textiles not produced in the same production unit	0,34	9%
174	Production of other textiles	1,03	26%
175	Production of woven, knitted and crocheted articles	1,09	27%
180	Production of clothes; preparation and dying of leather	0,98	25%
191	Tanning and preparation of leather	1,17	29%
192	Production of shoes	0,77	19%
193	Production of travel goods, handbags and similar goods; production of saddlery and harness	1,64	41%
201	Sawing, planing and impregnating wood	0,8	20%
202	Production of wooden sheets for plating, producing counterplating tables, laminated boards and other boards and panels	0,28	7%
203	Production of carpentry parts and pieces	0,41	10%
204	Production of wooden containers for buildings and construction	0,72	18%
209	Production of other wooden goods; production of cork, basketry and plaiting products	1,07	27%
210	Production of paper, cardboard and similar products	1,06	27%
221	Editing activities	1,44	36%
222	Printing activities	0,68	17%
223	Printing services activities	0,91	23%
230	Coking and production of petroleum refinery and nuclear fuel products	0,94	24%
241 - 243	Production of basic chemical substances/synthetic and artificial fibers	1,28	32%
251	Production of rubber goods	1,21	30%
252	Production of plastic goods	1,22	31%
261	Production of glass and glass goods	0,72	18%
269	Production of non-metallic mineral goods	1,43	36%
271	Basic iron and steel industries	0,96	24%
272	Precious and non-ferrous metals basic industries	1,72	43%
281	Production of metal goods for structural, tank, deposit and vapor generation use	0,94	24%

Continued...

289	Production of other metal goods and service activities related to metal working	1,1	28%
291	Production of general use machinery	1,27	32%
292	Production of special use machinery	1,13	28%
293	Production of domestic appliances	2,48	62%
341	Production of automotive vehicles and engines	1,42	36%
342	Production of undercarriages for automotive vehicles	1,9	48%
343	Production of automotive vehicle and engine parts, accessories and pieces	1,27	32%
350	Production of other types of transport equipment	1,88	47%
361	Production of furniture	1,07	27%
369	Manufacturing and tobacco product industries	0,93	23%
2421	Production of pesticides and other chemical goods for agricultural	2,77	69%
2422	Production of paint, varnish, coating, printing ink	1,56	39%
2423	Production of pharmaceutical goods and medical chemical substance	1,87	47%
2424	toiletries	1,56	39%
2429	Production of other chemical goods	1,79	45%
300 - 310 - 320 - 330	Production of office machinery, accounting and IT solution products; electric machinery and devices, radio, television and communication equipment and devices; medical, optical, precision instruments and watches	1,23	31%
	SECTOR INDICATOR	1,26	32%

Source: Author's elaboration.

The table above shows the level of Absorptive Capacity for each of the studied subsectors, measured as percentages: a company with 0% has no capacity to absorb external knowledge; 25% indicates low Absorptive Capacity, i.e., the company can absorb only 25% of the total external knowledge; 50% represents a medium level; 75% corresponds to a high level; and 100% implies that the company can absorb, assimilate, transform and exploit all external knowledge to which they have access.

The subsector with the highest level of Absorptive Capacity is the pesticides and other agricultural products manufacturing sector (69%- high level), while the subsector with the lowest Absorptive Capacity is wooden sheets manufacturing at 7%. Within the subsectors with a medium-high Absorptive Capacity, we find domestic appliance production (62%); close to the median, we can observe textile fibers preparation and sewing (54%), coffee products development (48%), the production of undercarriages for motor vehicles (48%) and other types of transport (47%), and finally the production of pharmaceutical goods (47%). Generally, the average level of Absorptive Capacity in Colombian manufacturing is 32%, close to a low level, which leads us to corroborate findings that companies in this sector are deficient in the area of implementing innovation.

In the subsectors with the highest level of Absorptive Capacity, we find the two sectors recognized in Colombia as "world class sectors" and representing pillars of the government's Productive Transformation Program: automotive parts and textiles, clothing, design and fashion. This finding implies that high impact could be generated by further development in these sectors because they have great potential to manage knowledge within companies and transform it into market innovations.

4.6. Results for the level of Absorptive Capacity in the Colombian Service Sector

Table 9 shows the results for the level of Absorptive Capacity for each of the service subsectors.

Table 9. Level of Absorptive Capacity in the Services Sector

ISIC	Subsector name	CAPAB	%
40	Electricity, gas, vapor and hot water supply	2,10	53%
41	Capturing, purifying and distributing water	1,56	39%
50	Automotive fuel and lubricant trade	0,84	21%
51	Wholesale trade except for automotive trade	1,95	49%
52	Retail trade except for automotive trade	1,86	47%
62	Air transport	1,14	29%
72	IT	1,85	46%
73	Research and development centers	3,07	77%
90	Waste and residual water removal, sanitation and similar activates	1,12	28%
851	Human health related activities	2,25	56%
921	Cinematography, radio and television activities and other entertainment	2,33	58%
8050	Private higher education	2,29	57%
551-552	Hotels and restaurants	1,13	28%
602-604	Passenger and cargo transportation by road	1,96	49%
641-642	Post and telecommunications	1,36	34%
6511-6512	Banking activities	0,92	23%
	SECTOR INDICATOR	1,73	43%

Source: Author's elaboration.

Among the subsectors with high Absorptive Capacity, we find research and development centers (77%). Subsectors around the median level are cinematography activities (58%), higher education (57%) and electricity, gas, and related utilities supply (53%). The subsectors with the lowest level of Absorptive Capacity are banking activities (23%) and trade in automotive vehicles, lubricants, and fuels (21%).

The average Absorptive Capacity in the Colombian service sector is 43%, close to a medium level, indicating greater Absorptive Capacity in the service sector than in the manufacturing sector.

For the Manufacturing sector, Absorptive Capacity is catalogued in the low range; companies in this sector do not take the fullest advantage of the external knowledge that can be acquired, a situation that is also expressed in their low level of innovation (DANE, 2012). This indicator corroborates the low levels of R&D in the country, where the majority of corporate investment in the manufacturing sector corresponds to innovations based on already existing knowledge and new products derived from new knowledge acquired by companies are not being generated (Langebaek and Vásquez, 2007).

The results obtained for the service sector in Colombia indicate a medium level of Absorptive Capacity, which is justified given that this sector represents over 50% of Colombian GDP, and in recent years, it has developed technologies that decrease transport costs. Among the primary factors differentiating the manufacturing and service sectors, we find that the service sector is labor intensive, which leads to the increasing specialization of human capital and thereby improves the dynamics of knowledge transfer in organizations. The companies from the service sector have better opportunities to acquire external knowledge because the nature of their activity implies the need for continued interaction between producer and client.

5. Conclusions, Limitations, and Future Research

This study adopted a statistical methodological approach that used various validation tools to provide both theoretical and empirical support for the measurement instrument obtained. Additionally, the obtained measurement instrument was validated using the manufacturing and service sectors in Colombia as analysis units to test the indicator. The sectors chosen for the designed indicator contribute a large proportion of Colombian GDP and boost economic growth thanks to various policies implemented by the government in different subsectors.

The low Absorptive Capacity obtained for both sectors questions the models and strategies for Knowledge Management used by the companies, especially in the Manufacturing sector, which has no subsector exhibiting a high level of Absorptive Capacity. Furthermore, these results show that a public policy effort to promote innovative activity in Colombia still has a long way to go. The response of the automotive and automotive parts sector is especially interesting in the context of government policies aimed at turning this into a world class sector; its highest level of innovativeness is consistent with the process of boosting knowledge absorption by taking advantage of external knowledge and generating more innovative activity.

Also interesting is the higher level of Knowledge Absorptive Capacity in the service sector, which reflects the growth of this sector in recent years and demonstrates that it is trying to offer higher value added to the market. However, we find that Colombian companies do not take advantage of alliances with entities in direct contact with scientific research and innovation. These entities are an important source of external knowledge, as the higher education and the research and development center subsectors show high levels of Knowledge Absorptive Capacity, which could be transferred to other sectors if companies recognize that establishing networks and/or alliances with this type of institution would present new opportunities and development potential.

Based on the proposed indicator, we have established the level of knowledge transfer and creation in the manufacturing and service sectors, contributing to the detection of deficiencies and opportunities within the full range of scientific research and innovation processes, especially in the case of subsectors that focus on development processes. Further, we identified those subsectors with significant lags in terms of knowledge and innovation generation.

The limitations of this research work include the use of the EDIT database, which presents some difficulties when using certain methodologies that could have been more appropriate for this type of research, although this was not an obstacle to achieving the proposed goals. Nevertheless, despite the fact that the developed indicator is adapted to the nature of the survey used, a future line of research could adapt the variables of this indicator in a Likert scale survey, which could be used to analyze different population groups at the organizational level and to establish a relationship between Absorptive Capacity and other strategic variables in the business field.

Bibliography

Ahlin, B., Drnovšek, M., and Hisrich, R. (2014). Exploring the moderating effects of absorptive capacity on the relationship between social networks and innovation. Journal for East European Management Studies, 19 (2), 213-235.

Barney, J. (1991). Firm Resources and sustained competitive advantage. Journal of Management, 1(1), 7-21.

Becker, W., and Peters, J. (2000).Technological opportunities, absorptive capacities and innovation. Article presented at the Eighth International Joseph A. Schumpeter Society Conference, Centre for Research in Innovation and Competition (CRIC), Manchester.

Boynton, A., Zmud, R., and Jacobs,G. (1994).The influence of IT management practice on IT use in large organizations. MIS Quarterly Review 18(3), 299–318.

Camisón, C., and Forés, B. (2010). Knowledge absorptive capacity: New insights for its conceptualization and measurement, Journal of Business Research, 63, 707-715.

Castellacci, F., and Natera, J. (2013). The dynamics of national innovation systems: A panel cointegration analysis of the coevolution between innovative capability and absorptive capacity. Research Policy, 42 (3), 579-594.

Cepeda-Carrion, G., Cegarra-Navarro, J., and Jimenez-Jimenez, D. (2012). The Effect of Absorptive Capacity on Innovativeness: Context and Information Systems Capability as Catalysts. British Journal of Management, 23, 110–129.

Chen, H., Qiao, S., and Lee, A. (2014). The impacts of different R&D organizational structures on performance of firms: Perspective of absorptive capacity. Journal of High Technology Management Research, 25, 83–95.

Chang, Ch., Chen, Y., and Lin, J. (2014). The impacts of different R&D organizational structures on performance of firms: Perspective of absorptive capacity. R&D Management, 44(5), 466-483.

Churchill, Gilbert A., Jr. (1979), A Paradigm for Developing Better Measures of Marketing Constructs, Journal of Marketing Research, 16 (February), 64-73.

Cockburn, I., Henderson, R. and Stern, S. (2000). Untangling the origins of competitive advantage. Strategic Management Journal, 21, 1123-1145.

Cohen, W., and Levinthal, D. (1989). Innovation and learning: The two faces of R&D, Economic Journal, 99 (297), 569-596.

Cohen, W., and Levinthal, D. (1990). Absorptive capacity: A new perspective on learning and innovation, Administrative Science Quarterly, 35 (1), pp. 128-152.

Cronbach, L. (1951). Coefficient alpha and the internal structure tests. Psychometryka, 16 (3), 297-333.

DANE (2011). Methodological document: Technological Development and Innovation Survey en la Manufacturing sector – EDIT. Accessed September 18 2012 www.dane.gov.co.

DANE (2012). Press bulleting - Technological Development and Innovation Survey en la Manufacturing sector – EDIT V 2009-2010. Accessed September 18 2012 www.dane.gov.co.

DANE (2013). Press bulleting - Technological Development and Innovation Survey en el Service sector – EDITS III 2010-2011. Accessed February 3 2013 www.dane.gov.co.

Datta, A. (2011). Combining Networks, Ambidexterity and Absorptive Capacity to Explain Commercialization of Innovations: A Theoretical Model from Review and Extension. Journal of Management and Strategy, 2 (4); December 2011.

Diamantopoulos, A., and Winklhofer, H. (2001). Index construction with formative indicators: An alternative to scale development. Journal of Marketing Research, 38(2), 269–277.

Dinar, Z. (2014). Transboundary pollution, R&D spillovers, absorptive capacity and international trade. International Journal of Economics and Financial Issues, 4 (3), 501-513.

Dyer J., and Singh, H. (1998). The relational view: cooperative strategies and sources of inter-organizational competitive advantage. Academy of Management Review 23(4), 660-679.

Egbetokun, A., and Savin, I. (2014). Absorptive capacity and innovation: When is it better to cooperate? Journal of Evolutionary Economics, 24 (2), 399-420.

Eisenhardt, K., and Martin, J. (2000). Dynamic capabilities: What are they? Strategic Management Journal, 21 (10-11), 1105-1121.

Escribano, A., Fosfuri, A., Tribo, J.A. (2009). Managing external knowledge flows: the moderating role of absorptive capacity. Research Policy 38(1), 96–105.

Ferreras-Méndez, J., Newell, S., Fernández-Mesa, A., and Alegre, J. (2015). Depth and breadth of external knowledge search and performance: The mediating role of absorptive capacity. Industrial Marketing Management, In Press.

Flatten, T., Engelen, A., Zahra, A., and Brettel, M. (2011). A measure of absorptive capacity: Scale of development and validation. European Management Journal. 29, 98-116.

Flor, M., and Oltra, M. (2011). La Relación entre la Knowledge Absorptive Capacity externo and la estrategia empresarial: un análisis exploratorio. [The relationship between Knowledge Absorptive Capacity and external business strategy: an exploratory analysis.] Revista Europea de Dirección and Economía de la Company, 20 (1), 69-88.

García-Morales, V., Bolívar-Ramos, M., Martín-Rojas, R. (2014). Technological variables and absorptive capacity's influence on performance through corporate entrepreneurship. Journal of Business Research, 67 (7), 1468-1477.

Gebauer, H., Worch, H., and Truffer, B. (2012). Absorptive capacity, learning processes and combinative capabilities as determinants of strategic innovation. European Management Journal, 30, 57– 73.

George, G., Zahra, S., Wheatley, K., Khan, R. (2001). The effects of alliance portfolio characteristics and absorptive capacity on performance. A study of bio-technology firms. The Journal of High Technology Management Research, 12(2), 205–226.

Gluch, P., Mathias, G., and Liane, T: (2009). An absorptive capacity model for green innovation and performance in the construction industry. Construction Management and Economics 27, 451–464.

Grant, R. (1996). Prospering in dynamically-competitive environments: Organizational capability as knowledge integration, Organization Science, 7 (4), 375-387.

Grant, R. M. (1991). The Resource-based Theory of Competitive Advantage: Implications for Strategy Formulation. California Management Review, 33(3), 114-135.

Hadi, Z., Farzam, V., Satarifar, M., and Bakhshi, L. (2011). The Relationship between Knowledge Transfer and Competitiveness in "SMES" with Emphasis on Absorptive Capacity and Combinative Capabilities. International Business and Management, 2 (1), 59-85.

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E., and Tatham, R.L. (1999). Multivariate data analysis (2nd ed.). Upper Saddle River, N.J.: Pearson Education Inc.

Heeley, M. (1997). Appropriating rents from external knowledge: the impact of absorptive capacity on firm sales growth and research productivity. Frontiers of Entrepreneurship Research, 17,390–404.

Itami, H. (1987). Mobilizing Invisible Assets. Harvard University Press, Cambridge, MA.

Jansen, J., Van Den Bisch, F., and Volberda, H. (2005). Managing potential and realized absorptive capacity: How do organizational antecedents matter? Academy of Management Journal, 48 (6), 999-1015.
Jensen, M., Johnson, B., Lorenz, E., Lundvall, B. (2007) Forms of knowledge and modes of innovation. ResearchPolicy, 36, 680-693.

Jiménez-Barrionuevo, M., García-Morales, V., and Molina, L. (2011). Validation of an instrument to measure absorptive capacity. Technovation 31, 190–202.

Jiménez-Barrionuevo, M., Morales, V., Molina, L. (2011). Validation of an instrument to measure absorptive capacity. Technovation, 31, 190-202.

Kauppi, K., Brandon-Jones, A., Ronchi, S., van Raaij, E. (2013). Tools without skills: Exploring the moderating effect of absorptive capacity on the relationship between e-purchasing tools and category performance. International Journal of Operations and Production Management, 33 (7), 828-857.

Kostopoulos, K., Papalexandris, A., Papachroni, M., and Ioannou, G. (2011). Absorptive capacity, innovation, and financial performance. Journal of Business Research, 64, 1335–1343.

Lane, P., and Lubatkin, M. (1998). Relative absorptive capacity and inter-organizational learning, Strategic Management Journal, 19 (5), 111-125.

Lane, P.; Koka, B. and Pathak, S. (2006). The reification of absorptive capacity: A critical review and rejuvenation of the construct. Academy of Management Review, 31 (4), 833-863.

Langebaek, A. and Vásquez, D. (2007). Determinantes de la actividad innovadora en la manufacturing sector colombiana. [Determinants of innovative activity in the Colombian manufacturing industry. Borradores de Economía, 433, 1-36.

Lau, A., and Lo, W. (2015). Regional innovation system, absorptive capacity and innovation performance: An empirical study. Technological Forecasting and Social Change, 92, 99-114.

Leal-Rodríguez, A., Roldán, J., Ariza-Montes, A., and Leal-Millán, A. (2014). From potential absorptive capacity to innovation outcomes in project teams: The conditional mediating role of the realized absorptive capacity in a relational learning context. International Journal of Project Management, 32(6), 894-907.

Liao, S., Fei, W., and Chen, C. (2007). Knowledge sharing, absorptive capacity, and innovation capability: An empirical study of Taiwan's knowledge-intensive industries. Journal of Information Science. XX (X), 1-20.

Luo, A. (1997). Partner selection and venturing success: the case of Joint Ventures with firms in the People's Republic of China. Organization Science 8(6), 648–662.

MacKenzie, S.; Podsakoff, P., and Jarvis, C. (2005). The Problem of Measurement Model Misspecification in Behavioral and Organizational Research and some Recommended Solutions. Journal of Applied Psychology, 90 (4), 710-730.

Mangematin, V., and Nesta, L. (1999). What kind of knowledge can a firm absorb? International Journal of Technology Management, 18 (3–4), 149–172.

Martins, J. (2014). Operating Factors That Help to Improve Performance in Subsidiaries with Low Absorptive Capacity. Journal of East-West Business, 20 (3), 162-183.

Máynez-Guaderrama, A., Cabazos-Arroyo, J., and Nuño-De La Parra, J. (2012). La influencia de la cultura organizacional and la absorptive capacity sobre la transferencia de knowledge tácito intra-organizacional. [The influence of organizational culture and the absorptive capacity of the tacit intra-organizational knowledge transfer.] Estudios Gerenciales, 28 (Special Edition) 191-211.

Minbaeva, D.; Pedersen, T.; Bjorkman, I.; Fey, C., and Park, H. (2003). MNC knowledge transfer, subsidiary absorptive capacity, and HRM. Journal of International Business Studies, 34 (6), 586-599.

Montinaria, L. and Rochlitz, M. (2014). Absorptive capacity compared: Evidence from sectoral data of OECD, Asian and Latin American countries. Applied Econometrics and International Development, 14 (2), 25-46.

Mowery, D., and Oxley, J. (1995). Inward technologies transfer and competitiveness: The role of national innovation systems, Cambridge Journal of Economics, 19 (1), 67-93.

Murovec, N. and Prodan, I. (2009). Absorptive capacity, its determinants, and influence on innovation output: cross-cultural validation of the structural model, Technovation, 29 (12), 859-872.

Nieto, M., and Quevedo, P. (2005). Absorptive capacity, technological opportunity, knowledge spillovers, and innovative effort. Technovation 25(10), 1141–1157.

Nugraha, T. (2011). Searching for Potential and Realized Absorptive Capacity of the Firm: The Case of Japanese Joint Ventures in Indonesia. The IUP Journal of Knowledge Management, Vol. IX (4), 54-75.

Nunnally J. (1978). Psychometric theory. 2nd edition. New York: McGraw-Hill.

OECD (2002). Proposed Standard Practice for Surveys for Research and Experimental Development. Frascati Manual 2002, OECD, Paris.

Park, T., and Rhee, J. (2012). Antecedents of knowledge competency and performance in born globals: The moderating effects of absorptive capacity. Management Decision, 50 (8), 1361-1381.

Patterson, W., and Ambrosini, V. (2015). Configuring absorptive capacity as a key process for research intensive firms. Technovation, 36/37, 77-89.

Pearson, K. (1986). Mathematical contributions to the theory of evolution II. Regresion heredity and panmixia. Philosophical Transactions of the Royal, 15, 246-263.

Peteraf, M. (1993). The cornerstones of competitive advantage: a resource- based view. Strategic Management Journal, 14 27-35.

Petroni, A. (1998). The analysis of dynamic capabilities in a competence-oriented organization. Technovation, 18 (3), 179-189.

Pisano, G. (1994). Knowledge, integration, and the locus of learning: an empirical analysis of process development. Strategic Management Journal, 15, 85-100.

Popaitoon, S., and Siengthai, S. (2014). The moderating effect of human resource management practices on the relationship between knowledge absorptive capacity and project performance in project-oriented companies. International Journal of Project Management, 32 (6), 908-920.

Ritala, P., and Hurmelinna, P. (2013). Incremental and Radical Innovation in Coopetition - The Role of Absorptive Capacity and Appropriability. Journal of Product Innovation Management, 30(1), 154–169.

Robertson, P., Casali, G., and Jacobson, D. (2012). Managing open incremental process innovation: Absorptive Capacity and distributed learning Managing open incremental process innovation: Absorptive Capacity and distributed learning. Research Policy, 41, 822– 832.

Schildt, H., Keil, T., and Maula, M (2012). The temporal effects of relative and firm-level absorptive capacity on inter-organizational learning. Strategic Management Journal, 33, 1154–1173.

Schuschny, A., and Soto, H. (2009). Guía metodológica Diseño de indicators compuestos de desarrollo sostenible. Documento de Trabajo, Comisión Económica para América Latina and el Caribe (CEPAL). [Methodological Design Guide for composite indicators of sustainable development. Working Paper, Economic Commission for Latin America and the Caribbean (ECLAC).

Sciascia, S., D'Oria, L., Bruni, M., and Larrañeta, B. (2014). Entrepreneurial Orientation in low- and medium-tech industries: The need for Absorptive Capacity to increase performance. European Management Journal, 32 (5), 761-769.

Seo, Y., Chae, S., and Lee, K. (2015). The impact of absorptive capacity, exploration, and exploitation on individual creativity: Moderating effect of subjective well-being. Computers in Human Behavior, 42, 68-82.

Su, Z., Ahlstrom, D., Li, J., and Cheng, D. (2013). Knowledge creation capability, absorptive capacity, and product innovativeness. R&D Management, 43(5), 473-485.

Sullivan, D. (1994). Measuring the degree of internationalization of a firm. Journal of International Business Studies, 25 (2), 325-42.

Szulanski, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practice within the firm. Strategic Management Journal, 17, 27-43.

Todorova, G., and Durisin, G. (2007). Absorptive capacity: Valuing a reconceptualization. Academy of Management Review, 32 (3), 774-786.

Tsai, W. (2002). Social structure of 'coopetition' within a multiunit organization: coordination, competition, and intra-organizational knowledge sharing. Organization Science, 13(2), 179-90.

Van Den Bosch, F., Volberda, H., and de Boer, M. (1999). Co-evolution of firm absorptive capacity and knowledge environment: organizational forms and combinative capabilities. Organization Science, 10 (5), 551-568.

Vega-Jurado, J., Gutiérrez-Gracia, A., and Fernández-de-Lucio, I. (2008) Analyzing the determinants of firm's absorptive capacity: beyond R&D. R&D Management, 38 (4), 392-405.

Veugelers, R. (1997). Internal R&D expenditures and external technology sourcing. Research Policy, 26(3), 303–315.

Wang, W., Liu, L., Feng, Y., Wang, T. (2014). Innovation with IS usage: Individual absorptive capacity as a mediator. Industrial Management and Data Systems, 114 (8), 1110-1130.

Waranantakul, W., and Ussahawanitchakit, M. (2012). Marketing knowledge absorptive capacity and marketing performance: an empirical investigation of food product exporting businesses in Thailand. International Journal of Business Strategy, 12 (3), 62-80.

Wernerfelt B. (1984). A resourced based view of the firm. Strategic Management Journal, 5 (2), 171-180.

Wu, A., and Voss, H. (2015). When does absorptive capacity matter for international performance of firms? Evidence from China. International Business Review, 24 (2), 344–351.

Xiong, G., and Bharadwaj, S. (2011). Social Capital of Young Technology Firms and Their IPO Values: The Complementary Role of Relevant Absorptive Capacity. Journal of Marketing, 75 (6), 87–104.

Zahra, S., and George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension, Academy of Management Review, 27 (2), 185–203.

Zollo, M.; Winter, S. (2002). Deliberate Learning and the Evolution of Dynamic Capabilities. Organization Science, 13 (3), 339-351.

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