



# Knowledge absorptive capacity: New insights for its conceptualization and measurement<sup>☆</sup>

César Camisón<sup>\*</sup>, Beatriz Forés<sup>\*</sup>

Department of Business Administration and Marketing, Universitat Jaume I, Campus Riu Sec, E-12071 Castellón, Spain

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## ABSTRACT

The processes for absorbing external knowledge become an essential element for innovation in firms and in adapting to changes in the competitive environment. Despite the huge growth in the absorptive capacity literature, a methodological gap still remains about a certain ambiguity in the definition of the construct specifying its theoretical domain and dimensionalization, and a lack of validation of the construct in most studies. The aim of this paper is to contribute to the literature on absorptive capacity through the creation and validation of two scales, justified with a thorough analysis of the literature, to measure the key components of the absorptive capacity construct: potential and realized absorptive capacities. The study includes confirmatory factor analysis on a sample of 952 Spanish firms to verify that the scales meet the psychometric properties the literature requires. The study results confirm the validity of the proposed scales and support their consolidation as a commonly used instrument with which to measure absorptive capacity.

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## 1. Introduction

In a dynamic and turbulent environment, knowledge represents a critical resource to create value and to develop and sustain competitive advantages (Tece et al., 1997). However, rapidly changing environments, technologies and rules of competitiveness exacerbate the problems organizations face in attaining self-sufficiency in knowledge creation. An inward looking approach to knowledge creation, in which the firm relies on its own resources, appears to be a conservative strategic option, as in that case firms miss out on the dynamic effects of interaction between internal and external knowledge. External knowledge enables the firm's internal knowledge to be extended by stimulating competitiveness and innovation (Matusik and Heeley, 2005).

Absorptive capacity has become one of the most significant constructs in the last twenty years precisely because external knowledge resources are so important. Absorptive capacity is the dynamic capacity that allows firms to create value and to gain and sustain a competitive advantage through the management of the external knowledge. Since the publication of Cohen and Levinthal's

(1989) work on absorptive capacity, numerous theoretical and empirical studies have analyzed firms' capacity to absorb knowledge. The absorptive capacity concept shows sufficient flexibility to be applied to different units of analysis and in a variety of research fields such as industrial organization, organizational learning, strategic management and innovation management (Zahra and George, 2002).

Nonetheless, despite the huge growth in the absorptive capacity literature, certain important gaps still remain. Specifically, the definition of the construct and its antecedents is sometimes ambiguous, and most studies do not validate it (Lane et al., 2006; Van den Bosch et al., 2003). Clearly, the intangible nature of the construct represents a hurdle to its conceptualization, but the problems outlined above are mainly due to the fact that the literature adopts the concept without questioning its scope and its relationship to other constructs with which knowledge absorptive capacity relates to. According to Bagozzi (1982), measurement is not an isolated problem of theoretical conceptualization, but rather an empirical activity that gives meaning to the theoretical variables in models. Consequently, accuracy in the conceptual definition of the construct, the appropriate delimitation of its external limits and its internal structure (dimensionality), and its reliable and valid measurement require maximum attention in the field of strategy.

Most studies into absorptive capacity use proxy variables relating to firms' R&D activity as an indicator of this capacity, following the research line of Cohen and Levinthal (1990). Other proxies include patents (e.g. Zhang et al., 2007), number of publications (e.g. Mangematin and Nesta, 1999), and number of employees with higher education qualifications (e.g. Caloghirou et al., 2004). However, these

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<sup>\*</sup> Corresponding authors. Tel.: +34 964 728558; fax: +34 964 728629.

E-mail addresses: camison@emp.uji.es (C. Camisón), bfores@emp.uji.es (B. Forés).

objective unidimensional measures meet with increasing criticism, as they turn out to be insufficient to capture the richness of such a complex construct.

A limited series of studies (e.g. Jansen et al., 2005; Lane et al., 2001; Liao et al., 2007; Vinding, 2006; Tu et al., 2006; Wong et al., 1999) attempt a more in-depth study of this process by formulating a multi-dimensional operationalization of absorptive capacity. They develop different multi-item instruments covering the set of aspects that embody absorptive capacity, such as methods of compensation, dominant logic, knowledge base, management practices, strategy, organizational structure, information management systems and organizational culture. Despite these methodological endeavors, the conceptualization of absorptive capacity still lacks a firm base in the theory, and likewise, the consolidation of a commonly used instrument with which to measure the construct is long overdue.

This controversy lies behind the objective to compile a state-of-the-art of the absorptive capacity construct, to provide a rigorous conceptualization grounded in the theory and to develop reliable, valid scales to operationally measure its key components from a process perspective. To this end, this study attempts to rectify the content deficiencies in the literature on the construct by specifying its theoretical domain and dimensionalization. Interest in absorptive capacity and the most far-reaching contributions (Lane et al., 2006; Van den Bosch et al., 1999; Zahra and George, 2002) begin by extending the knowledge-based approach (Kogut and Zander, 1992; Nonaka and Takeuchi, 1995), and for this reason, the conceptualization of the paper follows this theoretical framework. This study therefore constructs two multi-dimensional measurement models for potential and realized absorptive capacities that allow extending and empirically validating the theoretical contribution of Zahra and George (2002). In order to further the rigorous empirical validation of the scales' measurement, the study applies confirmatory factor analysis using structural equations modeling (SEM), which offers substantiated methodological guarantees.

The paper is structured in four parts. The first one presents a review of the literature on the absorptive capacity construct and its definitions in order to provide the foundations on which to construct two multi-dimensional and theoretically grounded measurement scales for its main components: potential and realized absorptive capacities. The second part examines how previous studies measure and test the absorptive capacity construct. This review allows us to operationalize potential absorptive capacity and realized absorptive capacity by means of two multi-item Likert-type measurement scales to evaluate their component indicators through manager self-evaluation. An electronic survey that 952 Spanish industrial firms completed, using a system of structural equations, subsequently validates the scales. The final part of the paper presents the study conclusions and the implications of the results.

## 2. Conceptualization of the absorptive capacity construct

### 2.1. Definition of absorptive capacity

The first step in giving empirical meaning to the theoretical concepts for building a study is to define the constructs (Wacker, 2004), in other words, to develop appropriate and valid measures of the constructs. The definition or specification of the construct domain involves two activities: representation from the literature to provide the concept with theoretical meaning and the specification of the aspects or dimensions that represent the construct (Churchill, 1979; DeVellis, 1991).

Cohen and Levinthal (1989) define absorptive capacity as the ability to learn from external knowledge through processes of knowledge identification, assimilation and exploitation. Based on previous studies such as Allen (1984), they hold that absorptive capacity is a by-product of an organization's R&D efforts. Since the

publication of this study, R&D has been considered as a key factor in organizational learning.

In a later paper they revise this original definition, putting forward a new view with a greater focus on the cognitive aspects underlying the learning process. In this second approach, Cohen and Levinthal (1990) redefine the absorptive capacity construct as the capacity of a firm to value, assimilate and apply, for commercial ends, knowledge from external sources. This new approach considers absorptive capacity as a by-product not only of R&D activities, but also of the diversity or breadth of the organization's knowledge base, its prior learning experience, a shared language, the existence of cross-functional interfaces, and the mental models and problem solving capacity of the organization's members.

These definitions of absorptive capacity, framed within the context of technological knowledge, have proved cardinal to the conceptualization of the construct, to such an extent that very few subsequent studies have revised or expanded Cohen and Levinthal's definition. The literature applies the construct in a wide range of areas within the fields of economics and organizations, in accordance with the specific needs of each study, without questioning the inherited concept, in other words, without providing a theoretically justified concept grounded in the literature. The studies (e.g., Arbussa and Coenders, 2007; George et al., 2001; Liao et al., 2003) that modify Cohen and Levinthal's definition alter its dimensionalization only slightly, and they do so by limiting the construct to two dimensions: the first, related to the evaluation, acquisition and assimilation of external knowledge, and the second related to its internal dissemination and application. Matusik and Heeley (2005) develop a three-level model of absorptive capacity (individual, intra-organizational and organizational) and also focus on two components, in this case access to and assimilation of external knowledge. The only critical contributions with a certain level of originality are those of Mowery and Oxley (1995), Kim (1998), Lane and Lubatkin (1998), Dyer and Singh (1998), Van den Bosch et al. (1999), Zahra and George (2002) and Lane et al. (2006).

Lane and Lubatkin (1998) are the first scholars to reinterpret the construct that Cohen and Levinthal (1989) introduce. These authors define a new construct that they term relative absorptive capacity, in which the main difference from the construct of Cohen and Levinthal lies in its context of analysis. Hence, while Cohen and Levinthal (1989, 1990) analyze firms' capacity to absorb knowledge from a sector, Lane and Lubatkin (1998) analyze the capacity of organizations to absorb from other organizations. These authors define relative absorptive capacity as the ability of a (student or receiver) firm to value, assimilate and apply knowledge derived from another (teacher or sender) firm. After demonstrating that R&D expenditure explains only 4% of variance in inter-organizational learning, Lane and Lubatkin conclude that the relative characteristics of the two organizations, and in particular the relation between their knowledge processing and application systems determine to a large extent an organization's ability to absorb knowledge from another organization.

The most far-reaching reconceptualization of the absorptive capacity construct since Cohen and Levinthal is that which Zahra and George (2002) propose. Zahra and George (2002) link the construct to a set of organizational routines and strategic processes through which firms acquire, assimilate, transform and apply knowledge with the aim of creating a dynamic organizational capacity. According to Zahra and George (2002), the four capacities or processes their definition introduces represent the four dimensions of absorptive capacity which combine naturally and build upon one other to produce a dynamic organizational capability (Teecce et al., 1997). Hence, this study now reformulates Cohen and Levinthal's (1989) original three-dimensional model with four dimensions and, at the same time, groups these into two components: potential absorptive capacity (PACAP) and realized absorptive capacity (RACAP). PACAP comprises the dimensions of knowledge acquisition—both the

capacity to value knowledge as [Cohen and Levinthal \(1990\)](#) introduce and the capacity to acquire knowledge—and of assimilation. In turn, realized absorptive capacity consists of knowledge transformation and application.

According to [Zahra and George \(2002\)](#) these two components perform separate but complementary roles. Firms cannot apply external knowledge without acquiring it. Similarly, certain organizations may develop abilities to acquire and assimilate external knowledge, but are not able to transform and apply this knowledge, in other words, to turn it into competitive advantage. Hence, both subsets of ACAP meet a necessary but insufficient condition to generate value for the firm. Building from a thorough review of the main papers published on absorptive capacity, [Lane et al. \(2006\)](#) define the construct as a firm's ability to use knowledge from the external environment through three sequential processes: (1) the recognition and understanding of new potentially valuable external knowledge through exploratory learning; (2) the assimilation of valuable new knowledge through transformative learning; and (3) the use of assimilated knowledge to create new knowledge and commercial outputs through exploitative learning. As in most studies on absorptive capacity, this definition, oriented to the learning process, introduces three of [Cohen and Levinthal's \(1989, 1990\)](#) classic dimensions. However, [Lane et al. \(2006\)](#) implicitly refer to transformation capacity by considering that external knowledge is assimilated through transformative knowledge, by combining it with existing knowledge.

Nonetheless, [Todorova and Durisin \(2007\)](#) question whether knowledge assimilation and knowledge transformation capacities are two different sequential processes. These authors argue that transformation capacity is not the phase that follows assimilation, but rather an alternative process, thus defining absorptive capacity as a firm's capacity to value, acquire, assimilate or transform, and exploit external knowledge. [Todorova and Durisin \(2007\)](#) argue that when external knowledge fits with the firm's cognitive schemas, assimilation of knowledge takes place that leads directly to its exploitation or application, without this knowledge having to be previously transformed. In contrast, when the external knowledge or ideas do not fit with existing internal knowledge structures, the knowledge or ideas are transformed. In this case, individuals' cognitive structures should be modified to adapt an idea or situation that they cannot assimilate.

The present study follows [Zahra and George \(2002\)](#) and introduces the transformation process into the traditional notion of absorptive capacity. Although the literature implicitly includes the transformation capacity into the assimilation capacity, due to their dependence, these two capacities should be explicitly separated, since they depend on processes of a different nature within the organization and are part of different components (PACAP vs. RACAP). Although a firm may be able to identify, understand and assimilate external knowledge, the firm may not be able to integrate such knowledge with its previously existing knowledge. However, in contrast to [Todorova and Durisin \(2007\)](#) when a firm decides to acquire external knowledge, regardless of whether such knowledge relates to the base and structure of the firm's existing knowledge, the knowledge must be understood, comprehended, analyzed and codified, since the knowledge comes from very different organizational cultures, systems and practices. This phase comes before the acquired knowledge can be diffused and integrated into the firm's existing internal routines, processes and knowledge.

Despite their important contribution, [Zahra and George \(2002\)](#) do not provide a clear, concise theoretical definition of the construct. The basic limitation of their conceptualization is rooted in the use of the condition of complementarity to describe the relationships between the four dimensions (acquisition, assimilation, transformation and application) of the construct and between the two components of the absorptive capacity (PACAP and RACAP). The condition of complementarity does not allow an appropriate definition of the constructs and therefore does not meet the requirement for unambiguous definitions ([Wacker, 2004](#)). This paper's contribution of value rests on an appropriate definition by factorial analysis serving as the basis for

the analysis of covariances shared by the dimensions and components under the latent model ([Law et al., 1998](#); [Cheung, 2008](#)).

Consequently, this study defines absorptive capacity as the systematic, dynamic capacity that exists as two subsets of potential and realized absorptive capacities. PACAP, which knowledge acquisition and assimilation capabilities show, captures a firm's efforts expended in valuing, acquiring and assimilating new external knowledge. RACAP, which is reflected in knowledge transformation and application, represents the firm's ability to integrate and reconfigure the existing internal knowledge and the newly assimilated knowledge and to incorporate this transformed knowledge into firms' systems, processes, routines and operations, not only to refine existing knowledge and competences but also to create new operations and competences.

## 2.2. Dimensions of absorptive capacity

[Shenkar et al. \(1995\)](#) stipulate that the definition of a construct domain must fulfill two requirements: the construct must be testable, in other words, one must be able to operationalize its dimensions; and the construct must also be global, that is, incorporate the dimensions that different classifications propose.

Following the line of authors who uphold the need to study absorptive capacity from a dynamic or process-oriented perspective ([Lane et al., 2006](#); [Zahra and George, 2002](#)), and in accordance with the authors' interpretation of the construct, four different dimensions—acquisition, assimilation, transformation and application—exhaustively cover the domain of absorptive capacity (see [Table 1](#)).

The literature often confuses application capacity with innovation capacities and even with innovative performance or output ([Van den Bosch et al., 2003](#)). This conceptual confusion is mistaken, since the two constructs refer to different contents. Although absorptive capacity can affect performance and competitive advantage through the exploitation of

**Table 1**  
Dimensions of absorptive capacity.

Dimensions	Definition	Antecedents
Acquisition	Acquisition capacity is a firm's ability to locate, identify, value and acquire external knowledge that is critical to its operations.	<a href="#">Lane and Lubatkin (1998)</a> , <a href="#">Zahra and George (2002)</a> , <a href="#">Liao et al. (2003)</a>
Assimilation	Assimilation capacity refers to a firm's capacity to absorb external knowledge. This capacity can also be defined as the processes and routines that allow the new information or knowledge acquired to be analyzed, processed, interpreted, understood, internalized and classified.	<a href="#">Szulanski (1996)</a> , <a href="#">Zahra and George (2002)</a>
Transformation	Transformation capacity is a firm's capacity to develop and refine the internal routines that facilitate the transference and combination of previous knowledge with the newly acquired or assimilated knowledge. Transformation may be achieved by adding or eliminating knowledge, or by interpreting and combining existing knowledge in a different, innovative way.	<a href="#">Kogut and Zander (1992)</a> , <a href="#">Van den Bosch et al. (1999)</a>
Application	Application or exploitation capacity refers to the organizational capacity based on routines that enable firms to incorporate acquired, assimilated and transformed knowledge into their operations and routines not only to refine, perfect, expand and leverage existing routines, processes, competences and knowledge, but also to create new operations, competences, routines, goods and organizational forms.	<a href="#">Lane and Lubatkin (1998)</a> , <a href="#">Zahra and George (2002)</a>

external knowledge, these effects require additional resources and capacities (Matusik and Heeley, 2005; Zahra and George, 2002), such as innovation capacity (Liao et al., 2007). According to Leonard-Barton (1995) and Nonaka and Takeuchi (1995), the creation of knowledge is important, but the conversion of this knowledge into new products is the basis of superior performance. In this sense, both external learning capacity (absorptive capacity) and internal learning capacity (internal knowledge creation capacity) influence innovation capacity, which in the final instance is what determines innovative performance. Although both learning capacities are considered as two interrelated capacities of change (Levinthal, 1991), they are based on differentiated processes, routines and strategies.

Following Zahra and George (2002) and according to this paper's definition, these four dimensions are classifiable into two components: potential absorptive capacity (acquisition and assimilation) and realized absorptive capacity (transformation and application). This distinction is justifiable because, by defining two large blocks of capacities, the study of their multiple antecedents and outcomes, and the analysis of the relationships between both components are easier. In this sense, Zahra and George (2002) state that potential absorptive capacity affects competitive advantage through management flexibility and the development of resources and capacities, while realized absorptive capacity does so through the development of new products and processes. Although transformation and application (RACAP) is the primary source of innovation, sustained business innovation requires continuing renewal of knowledge stocks and assimilation into the firm's knowledge base (PACAP) to avoid competence traps. Consequently, the theoretical distinction between PACAP and RACAP suggests that externally acquired knowledge undergoes multiple iterative processes before the firm can successfully apply this knowledge to create value. In this sense, companies that intend fostering absorptive capacity process could inhibit this process if they do not foster both components.

### 3. Operationalization and measurement of the construct

#### 3.1. Construction of an absorptive capacity measurement scale

Van den Bosch et al. (2003) state the need of a clear distinction between the measurement of the construct and the measurement of its antecedents and consequences in order to specify its operationalization. For this reason, the authors propose to study the routines, the mechanisms and the activities that make up PACAP and RACAP as the tools with which to develop the constructs measures.

Starting from the conceptualization of the absorptive capacity carried out above and in line with Zahra and George's (2002) definition, the authors consider PACAP as a second-order latent factor shown by two dimensions: knowledge acquisition and assimilation capabilities; and RACAP as a second-order latent factor reflected by: knowledge transformation and application. Both PACAP and RACAP are therefore latent constructs (Law et al., 1998) which exist at a deeper and more embedded level than its dimensions (see Fig. 1).

Jansen et al. (2005) use this distinction between PACAP and RACAP to investigate which organizational antecedents are associated with each of the two components of absorptive capacity. Fosfuri and Tribó (2008) have also used it to empirically explore the antecedents of PACAP and the impact of PACAP on innovation performance.

This study justifies the attributes selected to operationalize each dimension on the base of a review of the main instruments proposed in the literature. Table 2 presents the final scales for PACAP and RACAP and a detailed list of the studies as antecedents of their use. Appendix A presents the description of the potential and realized absorptive capacity items that this study uses.

Combining the increasing proliferation of multi-dimensional measurement scales with the use of classification scales permits expressing the judgment and experience of managers in subjective measurements. Managerial self-evaluation of the firm's situation is growing as a way of

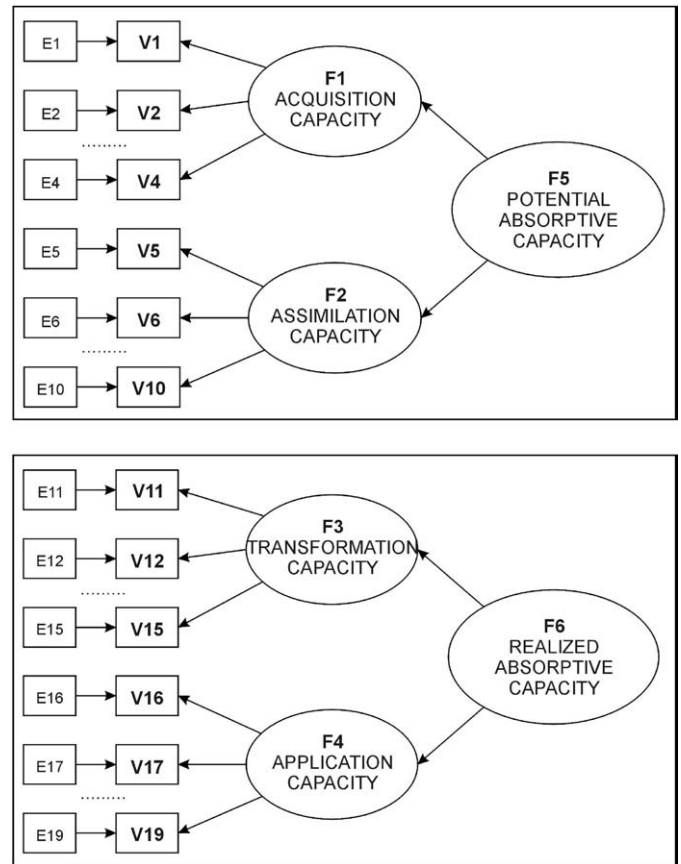


Fig. 1. Factor models to measure PACAP and RACAP constructs.

measuring firms' resources and capabilities, since various studies demonstrate that they are convergent measurements with equivalent objective indicators (Camisón, 2005). This study uses Likert-type self-evaluation scales, which reflect managers' perception of the strength of their firm's capacity to value, identify, acquire, assimilate, transform and apply new external knowledge, for each of the attributes of the construct as compared with their competitors in the industry. This procedure also has precedents in the distinctive competencies literature (e.g., Camisón, 2005; Hooley et al., 2005). The scale used has five points, where 1 is "much worse than our competitors", 3 is "on a par with our competitors", and 5 is "much better than our competitors".

Care is necessary to avoid the risk of bias (automatic, carelessly considered responses) implicit in a non-neutrally designed questionnaire, as is the case when all the items are positively drafted. To a certain extent, this problem is consubstantial with the resources-based approach, as the authors always define distinctive competences as sources of competitive advantage, and to do this, one must measure them in terms of increasing strength vis-à-vis competitors. In order to avoid "robot effect" responses, the authors opted for a control process that consisted of formulating certain items inversely (see Appendix A).

### 4. Validating the absorptive capacity measurement scale

#### 4.1. Database

To empirically validate the measurement instrument, the study uses a database of all Spanish industrial firms, with the exception of the energy sector, registered in Spain's National Statistics Institute Central Company Directory. The sample size consists of 2000 firms, to guarantee a maximum margin of error of  $\pm 2.2$  with a confidence interval of 95.5%. For the selection of units, the study follows stratified random sampling. The stratification criteria considered are size and

**Table 2**  
Scales and items of PACAP and RACAP constructs.

Items	Studies
<i>Potential absorptive capacity (CAPOT)</i>	
<i>Acquisition capacity</i>	
AD1 Knowledge of the competition	Lane et al. (2001), Nieto and Quevedo (2005), Tu et al. (2006)
AD2 Openness towards the environment	Caloghirou et al. (2004), Lane et al. (2001), Jansen et al. (2005), Nieto and Quevedo (2005), Soo et al. (2007), Tu et al. (2006)
AD3 R&D cooperation	Arbussa and Coenders (2007), Caloghirou et al. (2004), Jansen et al. (2005), Liao et al. (2003), Mangematin and Nesta (1999), Zahra and George (2002)
AD4 Internal development of technological competences	Arbussa and Coenders (2007), Tu et al. (2006)
<i>Assimilation capacity</i>	
AS1 Assimilation of technology	Jansen et al. (2005), Matusik and Heeley (2005), Wong et al. (1999)
AS2 Human resources	Caloghirou et al. (2004), Hayton and Zahra (2005), Liao et al. (2007), Nieto and Quevedo (2005), Tu et al. (2006), Vinding (2006)
AS3 Industrial benchmarking	Tu et al. (2006)
AS4 Involvement in spreading the knowledge	Arbussa and Coenders (2007), Caloghirou et al. (2004), Fosfuri and Tribó (2008), Soo et al. (2007)
AS5 Attendance at training courses and professional events	Caloghirou et al. (2004), Jansen et al. (2005), Soo et al. (2007)
AS6 Knowledge management	Matusik and Heeley (2005), Szulanski (1996)
<i>Realized absorptive capacity</i>	
<i>Transformation capacity</i>	
TR1 Transmission of IT-based knowledge	Jansen et al. (2005), Nieto and Quevedo (2005), Wong et al. (1999)
TR2 Renewal capability	Jansen et al. (2005)
TR3 Adaptation capacity	Jansen et al. (2005), Nieto and Quevedo (2005)
TR4 Exchange of scientific and technological information	Jansen et al. (2005), Lenox and King (2004), Szulanski (1996), Soo et al. (2007), Tu et al. (2006)
TR5 Integration of R&D	Vinding (2006)
<i>Application capacity</i>	
AP1 New knowledge exploitation	Jansen et al. (2005)
AP2 Application of experience	Lenox and King (2004), Soo et al. (2007)
AP3 Development of patents	George et al. (2001), Mangematin and Nesta (1999), Zahra and George (2002)
AP4 Technological proactiveness	Jansen et al. (2005)

industry. The population is classified into 14 sectors according to 3-digit SIC codes, and into four size groups according to the European Union's definition of micro, small, medium and large firms. The sample allocation procedure adopted in each group is that of optimal allocation. Within each group, the selection of units to be studied until reaching allocated size follows simple random sampling.

The study included gathering the information self-administered electronic questionnaires, following a set of procedures from Simsek and Veiga (2000) for the electronic survey technique. They used a website-based instrument for data collection, following the recommendations of Stanton and Rogelberg (2001) to plan and implement research on the Internet in order to avoid some technological pitfalls. Self-administered questionnaires made up of pre-coded questions suffer from a series of problems (Descombe, 1998: 105–107). To minimize their impact the study resorts to the set of procedures advised for research using electronic surveys which involve a modified version of Dillman's (2000) "tailored design method". This method has advantages such as the possibility of obtaining uniform interpretations making it possible to compare the use of standardized responses and the direct development of constructs based on measurements promoting the validity of the construct (Lyon et al., 2000: 1058). The study included sending the questionnaires by e-mail to the firm's President/Chairman / CEO, and to ensure the anonymity and security of the agents they took the measures recommended in the literature (Simsek and Veiga, 2001: 230–232). Field work took place between February and May 2007. The final number of firms that completed the questionnaire was 952, giving a response rate of 47.6%.

Each questionnaire consists of six sections and 127 questions. The database cited here has wider purposes than those presented in this study; the study therefore only uses and presents the questions and data relative to absorptive capacity. Appendix A presents the description of the items for measuring potential and realized absorptive capacity that appear in the questionnaire. In order to

prevent the risk that answers may not be independent if questions on the same dimension are presented in related groups; the study randomizes question presentation, mixing them with other items, as can be seen in their numbering in the questionnaire.

#### 4.2. Statistical techniques

To demonstrate the psychometric properties of reliability, validity and dimensionality of the scales, the study undertook confirmatory factor analysis, following Jöreskog (1969) and using SEM (Anderson and Gerbing, 1982; Hair et al., 1998). The study also used EQS 6.0 software (Bentler, 1995) and its estimation technique was the maximum likelihood method with robust estimators, as Satorra and Bentler (1994) recommend to alleviate the requirements of normality.

#### 4.3. Evaluation of the absorptive capacity measurement scale

##### 4.3.1. Scale dimensionality

Fig. 1 shows the structure of the two measurement models that this study attempts to validate. The study includes running two confirmatory factor analyses for both PACAP and RACAP constructs to verify that the individual items of each first-order factor represents the same theoretical concept, and that the theoretical dimensions of each second-order factor co-vary to reflect the same construct. The study tests goodness of fit of the estimated models using absolute, incremental and parsimonious fit indices, together with statistical significance levels and parameter validity.

The analyses of the factor models indicate certain modifications to the initial model, to achieve a good fit of the first- and second-order factors. Following the instructions of the LMTEST, the study does not include some items from the initial scale of PACAP (AS4, AS5) and some items from the initial scale of RACAP (TR3), leaving a final scale of 8 indicators for PACAP and 8 indicators for RACAP (see Table 3).

**Table 3**  
Confirmatory factor analysis of the potential absorptive capacity and realized absorptive capacity measurement scales.

Factors <sup>a</sup>	Standardized factor loadings	<i>t</i> values <sup>b</sup>	<i>R</i> <sup>2</sup>	Conjoint reliability
<i>Potential absorptive capacity</i>				0.863
Acquisition capacity	0.961 <sup>c</sup>		0.923	0.643
AD1	0.353	5.764	0.128	
AD2	0.628 <sup>c</sup>		0.394	
AD3	0.653	5.901	0.426	
AD4	0.741	5.991	0.548	
Assimilation capacity	0.958	56.335	0.917	0.675
AS1	0.621 <sup>c</sup>		0.386	
AS2	0.637	9.200	0.406	
AS3	0.581	9.238	0.337	
AS4	0.692	9.448	0.478	
<i>Realized absorptive capacity</i>				0.852
Transformation capacity	0.982		0.964	0.653
TR1	0.734		0.538	
TR2	0.694		0.482	
TR4	0.591		0.350	
TR5	0.402		0.153	
Application capacity	0.905		0.819	0.652
AP1	0.321		1.000	
AP2	0.625		0.390	
AP3	0.643		0.413	
AP4	0.692		0.480	

<sup>a</sup> See Appendix A for a full description of the items.

<sup>b</sup> The *t* values over 1.645 are significant at a level of 5% (one tail).

<sup>c</sup> Parameter equal to one to determine the scale of the latent construct.

The goodness of fit statistics show the dimensionality of the constructs proposed. Although some of the *R*<sup>2</sup> individual reliability index do not exceed the minimum required level of 0.5 (Bollen, 1989), in all cases their factor loadings are positive, statistically significant in the factor to which they were assigned, and zero in other factors. The standardized loadings are higher than the required minimum value of 0.5 (Anderson and Gerbing, 1982; Hair et al., 1998; Satorra and Bentler, 1994) except for three items (AD1, TR5, AP1), which came very close to the minimum level. The study therefore included these items so as not to weaken the definition of the respective constructs domains. Table 4 presents the fit indices for the first-, and second-order factor models. The indices as a whole enable us to confirm the goodness of fit of each of the two factor types for PACAP and RACAP.

#### 4.3.2. Scale reliability

The present study includes two methods to measure scale reliability; each method evaluated each one of the two facets of the scale: stability and internal consistency. The study uses the re-test method to evaluate scales stability, as previous studies (e.g., Conant et al., 1990: 373) suggest, because testing the stability of results over time is useful. This method consists of administering the same scales on two occasions to the same group of individuals, in conditions that are as similar as possible, thus enabling the comparison of results obtained at different points in time. Carrying out the re-test took approximately 45 days after the respondents had first completed the questionnaire. 250 firms received the questionnaire for the second time, and the response rate was 70.8%. The percentage of firms that re-affirmed their initial answers is above the minimum of 0.70 that Nunnally (1978) establishes. This result confirms the PACAP and RACAP scales stability.

The second property is internal consistency, which seeks to test which items should be retained in order to guarantee an error-free measurement scale. To evaluate the degree of internal consistency of the scales, the analyses include calculating the conjoint reliability index for each of the dimensions of the two scales, as Fornell and Larcker (1981) suggest. The study sets the minimum value at 0.6, as Churchill (1979) recommends for

exploratory studies. The results (see Table 3) show that the observable variables are representative of the latent constructs. The joint reliability both for each dimension of the PACAP and RACAP scales and the two structural models is above the minimum value of 0.6. The dimensions of PACAP and RACAP scales are accurately measured and the observable variables are representative of the latent concepts.

To evaluate the individual reliability of the indicators, the study uses the perturbations (*R*<sup>2</sup>) obtained during the two second-order factor analysis (Table 3). In general terms, most of the indicators of the dimensions reach or come very close to the minimum value of 0.5 (Hair et al., 1998). The scale meets the requirement of reliability.

#### 4.3.3. Scale validity

As far as content validity is concerned, and following Bollen (1989), all the items that comprise the scales of PACAP and RACAP result from a review of the absorptive capacity literature, and the study has taken the greatest care to ensure that they respond to the conceptual definition and that they reflect all the relevant dimensions.

As Bollen (1989: 188) admits, “many of the concepts in social sciences are incompletely formulated and defined, so that content validity is difficult to apply”. In these common situations, studies need to check construct validity. The most usual way of testing construct validity is checking both convergent validity and discriminant validity (Churchill, 1979; Bollen, 1989). Convergent validity shows that the assessment relates to what it should theoretically be related to, and therefore whether the scale relates to the items which could be correlated and whether integrating them to obtain a general measurement is appropriate. Discriminant validity is the degree to which two or more measurements designed to measure different theoretical constructs are not correlated. This test therefore estimates the degree to which a measurement scale reflects only characteristics from the construct measured and not attributes from other constructs.

The study uses SEM to test convergent validity in three ways: (1) with the incremental fit of each model, using the Bentler–Bonett Non-Normed Fit Index (BBNNFI), which would exceed the recommended minimum values of 0.9 (Bentler and Bonett, 1980); (2) verifying that the standardized factor loadings were greater than or near to the minimum value of 0.5 (Hair et al., 1998); and following Anderson and Gerbing (1982), and checking that all the factor loadings were statistically significant ( $t \geq 1.96$ ;  $\alpha = 0.5$ ).

To test the discriminant validity of a construct Anderson and Gerbing (1988) suggest the following procedure: first, they recommend to set the dimensions of a construct to be correlated and be termed the unconstrained model. Second, they propose to modify the unconstrained model with one of the correlations set to be 1.0 and in this case the model is a constrained model. If the Chi-square difference

**Table 4**  
Goodness of fit and composite reliability of the PACAP and RACAP measurement scales.

Goodness of fit statistics	Individual first-order factor models				Second-order factor model	
	ACQUI	ASSIMI	TRANSFO	APLICA	ACPOT	ACREAL
<i>Absolute measure</i>						
GFI	0.998	0.997	0.996	0.998	0.978	0.980
RMSEA	0.000	0.000	0.041	0.000	0.000	0.021
<i>Incremental measure</i>						
IFI	1.006	1.002	0.994	1.006	1.000	0.995
CFI	1.000	1.000	0.993	1.000	1.000	0.995
BB-NNFI	1.017	1.005	0.980	1.019	1.000	0.992
<i>Parsimonious measure</i>						
Normed Chi Square	0.960	1.403	1.641	0.874	1.960	1.715
Joint reliability	0.644	0.674	0.652	0.624	0.863	0.852

The recommended acceptable levels are: GFI  $\geq 0.90$ ; RMSEA  $\leq 0.80$ ; IFI  $\approx 1$ ; CFI  $\approx 1$ ; BB-NNFI  $\geq 0.9$ ; Normed Chi Square between 1 and 5; composite reliability  $\geq 0.7$  or  $\geq 0.5$  with a lower level of requirement.

**Table 5**  
Discriminant validity of the constructs.

Variable	Model	$\chi^2$	df	$\Delta\chi^2$
PACAP	1. Unconstrained model	35.28	19	–
	2. Acquisition–assimilation	41.45	20	6.17**
RACAP	1. Unconstrained model	30.86	19	–
	2. Transformation–application	31.76	20	0.90**
Absorptive capacity	1. Unconstrained model	226.85	95	–
	2. PACAP–RACAP	227.97	96	1.07*

$\Delta\chi^2 = \chi^2$  (unconstrained model) –  $\chi^2$  (constrained model).

A–B implies that constructs A and B are set to be completely correlated.

\*  $p$ -value < 0.05.

\*\*  $p$ -value < 0.01 level.

between the two models is significant, the two dimensions of the construct are significantly different and should not be merged into one dimension. All the Chi-square differences between the dimensions of PACAP and the dimensions of RACAP in Table 5 are significant; therefore, the study verifies discriminant validities as well as the Chi-square differences between the PACAP and RACAP constructs. The results also confirm that PACAP and RACAP are significantly different components of absorptive capacity.

Finally, the study verifies the criterion validity. This validity is the degree of correspondence between a measure and a criterion variable, and expresses the extent to which the construct behaves as theoretically predicted in relation to certain constructs with which the construct is associated (Bollen, 1989: 186). This type of validity may be concurrent or predictive. The study uses concurrent validity for demonstrations relating a measurement to other criteria assessed simultaneously or which exist at the same time. Predictive validity refers to the degree to which a measurement can predict future events and the criterion therefore occurs in the future.

A generally accepted way of checking concurrent validity is to use its correlation with some objective measurements included in the survey which serve as criterion variables for some scale indicators. This procedure also allows the verification of whether the measurement of capabilities on the basis of managers' perceptions is convergent with objective measurement on the basis of quantitative data. The study makes the comparison for item AP3, which correlates with the number of patents; item TR1, which correlates with the number of information technology-based innovations the firm introduced; item AD3, which correlates with the number of technological cooperation agreements the firm established; and item AS5, which correlates with the percentage of the firm's staff involved in external knowledge-based activities. Results indicate that Pearson's correlation coefficients are positive (0.45, 0.34, 0.37, and 0.30, respectively) and statistically significant ( $p < 0.01$ ).

A key problem in evaluating capabilities is the preservation of objectivity. One basic reason for the lack of confidence in the objectivity of managerial perceptions of the firm's capabilities lies in the broad margin of variation, which may lead to very serious evaluation errors (Grant, 1991: 121). In addition, many groups of people show "self-evaluation bias" (Gramzov et al., 2003). Managers may be reluctant to admit weaknesses by formulating over-optimistic judgments of their performance. If this risk always occurs, self-evaluation, rather than truly reflecting capabilities, will reflect the managers' own self-esteem. But management perceptions also present advantages as being more precise evaluations of complex constructs. Extensive previous literature postulates the validity of subjective measuring scales for a variety of constructs related to firms' capabilities (e.g., Camisón, 2005). Concurrent validity for the scales proposed by measuring PACAP and RACAP would lead to the conclusion that the risk of bias is not high, unlike the correlation between subjective and objective measures. Another fact supporting this conclusion is that a large number of items show an appreciable

standard deviation, thus reflecting a wide range of responses that do not always tally with a positive self-evaluation.

The method used to validate the measurement scales is also of particular interest in distinguishing sources of bias in the measurement caused by a single respondent approach from "true" relationships between constructs in latent variables. SEM is a useful method to examine concepts that are not directly observable and to estimate various multiple dependence relationships simultaneously with statistical efficiency. Furthermore, use of SEM directly incorporates error in estimating multiple dependence relationships caused by imperfect measurement of latent variables (Hair et al., 1998).

Analyzing the correlation between a measurement and criterion variables which may be estimated in the future is a method for testing predictive validity. The basic fundamental postulates of the RBV identify capabilities as basic sources of economic rents. For this reason, this study has selected organizational performance as the variable theoretically related to absorptive capabilities in order to test the predictive validity of the scales. To measure this variable the study uses data on return on assets (ROA) (as measure of financial profitability) from the 2007 annual accounts compiled in the database SABI (Iberian Balance Sheet Analysis System). This source has secondary data from 678 firms included in the sample on the date of consultation (November, 2008). Results indicate positive (0.55, 0.49) and significant correlations ( $p < 0.001$ ) between average items making up the scales for measuring PACAP and RACAP, and ROA.

## 5. Conclusions and main implications

This study advances understanding of the absorptive capacity construct by highlighting the importance of creating a valid, reliable measurement instrument that conceives of the construct as a dynamic capacity that exists as two subsets of potential and realized absorptive capacities which comprise different processes, capacities and organizational routines. For this reason, focusing on the organizational level of analysis and grounded on the theoretical contribution of Zahra and George (2002) and the terminology of factor analysis, this study proposes two multi-item measurement scales that capture PACAP and RACAP.

The advantage of these measurement instruments is that they are not limited to technological knowledge and consequently enable the examination of the processes of acquisition and assimilation (PACAP) and transformation and exploitation (RACAP) of other types of external knowledge such as, for example, different managerial techniques and practices, human resources management models, organizational structures, production know-how, knowledge about industrial design, experience in marketing and/or knowledge about new markets. The scales also ground in a thorough review of the literature, thus advantaging the conceptual and methodological delimitation of PACAP and RACAP from its antecedents and consequences (Van den Bosch et al., 2003). This distinction also helps with an analysis of the relationships between both components and an explanation of why certain firms are more efficient than others in using absorptive capacity to create value. Nonetheless, future empirical studies should further examine the theoretical specification of PACAP and RACAP in relation to the entire set of dynamic capacities with which they are closely associated, such as internal knowledge creation capacities and innovation capacities (Liao et al., 2007), and the interrelations that arise among them, given that this is a far from simple process.

The empirical study confirms that the measurement instruments developed in this paper meet the psychometric requirements of dimensionality, validity and reliability, and as such, they represent interesting tools for further development in future research. Despite the value of the contribution to the absorptive capacity literature, certain aspects of the models require continued reflection. Firstly, although the empirical results obtained by comparing the scales constructed for PACAP and RACAP are generally good, the study has

certain limitations. In this sense, one item in the ACAP scale (AD1) and two items in the PACAP scale (TR5 and AP1) present factorial loadings that do not exceed the minimum accepted value of 0.5. Although the authors may have removed these items from the model (since the results derived from the factorial analysis are still good), they preferred to keep them so as not to weaken the definition of PACAP and the PACAP constructs. Besides, although PACAP and RACAP correlate highly in this study (0.80), conceptually they do not always have to correlate, and other researchers may observe lower correlations if they administer the scale in a different context. Future studies may use the seven-point scales for obtaining a greater variance.

Secondly, the responses are subject to interpretation by individual managers. Thus, the study took into account only subjective information from the questionnaire for measuring company results. The authors positively tested the convergent and concurrent validity of the scales, although they are aware of the potential risk of single respondent bias. Surveys based on managerial self-assessment from a single person are vulnerable to internal validity threats from the research environment. The study attempted to minimize the impact of these risks with different procedures, but distinguishing source bias from true relationships without having multiple respondents or multiple methods is impossible.

Regarding the generalization of the results of this study, the finding is robust because the authors collected the data from a multi-industry sample. However, this research used a sample of Spanish firms, and as such, one should be cautious about generalizing the results. No specific reason points to the fact that nationality might bias the results in a predictable direction. However, to prove this conjecture and generalize the findings, one should apply this research to other countries. Further studies clearly need to take into account contingencies that can affect both PACAP and RACAP models, such as the external knowledge environment, type of industry, types of knowledge acquired and different organizational circumstances such as strategies for seeking and implementing external knowledge, since the models are not universal.

This latter contingency relates to the notion of equifinality in obtaining results, implicit in the conceptualization of absorptive capacity as a dynamic capacity, which implies that the processes or stages can be clearly seen, but that the routines and components to develop these processes cannot (Zahra and George, 2002). A further limitation of the proposed measurement instruments is the difficulty in discerning between the limits of each of the processes that make up potential and realized absorptive capacities, due to their strong interrelationships. However, the strong theoretical basis and process perspective adopted has facilitated the operationalization and measurement of both complex constructs.

PACAP and RACAP are not simultaneous processes since, for example, the tacit knowledge acquired and assimilated (PACAP) will not necessarily be transformed (RACAP) straight away, but may be accumulated over time and used in subsequent periods to better match the market conditions. The consideration of non-simultaneity in the processes involved in absorptive capacity entails the undertaking of empirical studies based on longitudinal data; they would allow the unfolding of each of these processes or capacities comprising PACAP and RACAP to be observed over time. However, the data this study employs is cross-sectional. The cross-sectional nature of the research into a series of dynamic capacities (PACAP and RACAP) allows us to analyze only a specific moment in time of the organizations, not their behavior over time. Although the approach used reduces this problem by means of measurement scales with items that reflect dynamic characteristics, longitudinal data is required in order to observe and examine the iterative processes that the externally acquired knowledge undergoes before the firm can successfully apply it to achieve a competitive advantage.

The introduction of size as a moderating variable in both suggested measurement models is another interesting area for future research. The inclusion of this variable allows us to test the equivalence of the proposed

measurement models by comparing the strength of the relationship between the dimensions of both constructs across groups of firms based on size (Cheung, 2008). Therefore, many avenues are available for future studies to extend and refine this research framework.

## Appendix A. Absorptive capacity

When responding to the following items, consider the firm's capacity to value, identify, acquire, assimilate, transform and apply new external knowledge. Evaluate the strength of the firm's competitive position for each item in relation to the average for direct competitors on a scale of 1 to 5, where 1 is much worse than competitors, 3 on a par with competitors, and 5 is much better than competitors.

AD1	3. Capacity to capture relevant, continuous and up-to-date information and knowledge on current and potential competitors.
AP1	6. The organization's capacity to use and exploit new knowledge in the workplace to respond quickly to environment changes.
AD2	8. Degree of management orientation towards waiting to see what happens, instead of concern for and orientation towards their environment to monitor trends continuously and wide-rangingly and to discover new opportunities to be exploited proactively. <sup>a</sup>
AP2	23. Degree of application of knowledge and experience acquired in the technological and business fields prioritized in the firm's strategy that enables it to keep itself at the technological leading edge in the business.
AP3	29. Capacity to put technological knowledge into product and process patents.
TR1	36. Capacity of the company to use information technologies in order to improve information flow, develop the effective sharing of knowledge and foster communication between members of the firm, including virtual meetings between professionals who are physically separated—Internet B2E portals, e-mail, teleworking etc.
AS1	44. Capacity to assimilate new technologies and innovations that are useful or have proven potential.
AS2	48. Ability to use employees' level of knowledge, experience and competencies in the assimilation and interpretation of new knowledge.
AS3	52. The firm benefits when it comes to assimilating the basic, key business knowledge and technologies from the successful experiences of businesses in the same industry.
AP4	57. Ability to respond to the requirements of demand or to competitive pressure, rather than innovating to gain competitiveness by broadening the portfolio of new products, capabilities and technology ideas. <sup>a</sup>
AD3	60. Frequency and importance of cooperation with R&D organizations—universities, business schools, technological institutes, etc.—as a member or sponsor to create knowledge and innovations.
TR2	66. Firm's awareness of its competences in innovation, especially with respect to key technologies, and capability to eliminate obsolete internal knowledge, thereby stimulating the search for alternative innovations and their adaptation.
AD4	69. Effectiveness in establishing programs oriented towards the internal development of technological acquisition of competences from R&D centers, suppliers or customers.
AS6	74. Ability to develop knowledge management programs, guaranteeing the firm's capacity for understanding and carefully analyzing knowledge and technology from other organizations.
TR4	75. Degree to which firm prevents all employees voluntarily transmitting useful scientific and technological information acquired to each other. <sup>a</sup>
TR3	80. Capacity to adapt technologies designed by other to the firm's particular needs
AS4	93. Degree to which company employees attend and present papers at scientific conferences and congresses, are integrated as lecturers at universities or business schools or receive outside staff on research attachments.
AS5	101. Attendance of training courses, trade fairs and meetings.
TR5	112. Capability to coordinate and integrate all phases of the R&D process and its inter-relations with the functional tasks of engineering, production and marketing.

The first column reflects the coding of the items in the PACAP and RACAP measurement scale included in Table 2. The number allocated to the items is a faithful reflection of the order of appearance on the questionnaire.

<sup>a</sup>The authors formulated these items on a reversed scale.

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