

Absorptive Capacity: Scale Development and Implications for Future Research

Capacité d'absorption : proposition de mesure et contributions à de futures recherches

Capacidad de absorción: propuesta de medida y contribuciones a futuras investigaciones

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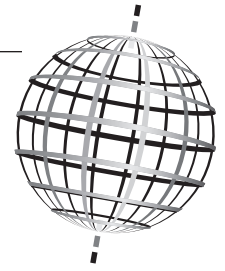
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Article abstract

In response to recent criticism concerning Absorptive CAPacity (ACAP) research we developed a new measure of this concept. Unlike past empirical studies that used proxies, this work tries to take advantage of past research in considering ACAP as a multilevel and multidimensional construct. This article, based on a large literature review, tries to fill this gap in developing and testing a scale of ACAP, composed of four factors and 18 items, that meets main validity and reliability criteria. We believe this research contributes to develop our understanding concerning ACAP and hope it facilitates the emergence of a new approach of the concept.

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RÉSUMÉ

En réponse aux récentes critiques concernant la capacité d'absorption nous avons développé une nouvelle échelle de mesure de ce concept. À l'opposé de la majorité des recherches empiriques passées qui ont eu recours à des proxys, la capacité d'absorption est considérée ici comme un construit multi-niveau et multi-dimensionnel. Cet article, qui s'appuie sur une large revue de littérature, essaye de répondre à cette problématique en proposant une échelle composée de quatre facteurs et 18 items, qui répond aux principaux critères de validité et de fiabilité. Cette recherche permet d'approfondir notre compréhension générale de la capacité d'absorption. Nous espérons que cela facilitera l'émergence d'une nouvelle approche du concept.

Mots clés : capacité d'absorption, échelle de mesure, modèle structurel

ABSTRACT

In response to recent criticism concerning Absorptive CAPacity (ACAP) research we developed a new measure of this concept. Unlike past empirical studies that used proxies, this work tries to take advantage of past research in considering ACAP as a multilevel and multidimensional construct. This article, based on a large literature review, tries to fill this gap in developing and testing a scale of ACAP, composed of four factors and 18 items, that meets main validity and reliability criteria. We believe this research contributes to develop our understanding concerning ACAP and hope it facilitates the emergence of a new approach of the concept.

Keywords: absorptive capacity, scale development, structural model

RESUMEN

En contestación a las recientes críticas respecto a la capacidad de absorción hemos desarrollado una nueva escala de medida de dicho concepto. Frente a la mayoría de las investigaciones empíricas pasadas que recurrieron a unos proxys, se considera aquí la capacidad de absorción como un construido multinivel y multidimensional. Este artículo, que estriba en una amplia revisión de la literatura, intenta contestar a esta problemática proponiendo una escala compuesta de cuatro factores y 18 ítems, que satisface a los principales criterios de validez y fiabilidad. Esta investigación permite profundizar nuestra comprensión general de la capacidad de absorción. Esperamos que facilite el surgimiento de un nuevo enfoque de dicho concepto.

Palabras claves: capacidad de absorción, escalas de medición, modelo estructural

The concept of Absorptive CAPacity (ACAP) has continuously grown in importance since Cohen and Levinthal (1990, p. 128) first defined it as “the ability to value new external information, to assimilate it and to apply it to commercial ends”. Based on the work of Zahra and George (2002) ACAP is nowadays perceived as having four dimensions (acquisition, assimilation, transformation and exploitation). Although much research has been done in the field, the diversity of the conceptualizations, operationalizations and the variety of settings involved limit the impact of previous works. One of the major weaknesses is that no multilevel scale integrating the four dimensions was validated, what appears all the more critical in SMEs (Liao, Welsch, & Stoica, 2003; Wang & Ahmed, 2007; Flatten et al. 2011).

Recent papers (Lane, Koka & Pathak, 2006; Todorova and Durisin, 2007; Volberda, Foss and Lyles, 2010) highlight also the fact that past research do not to take into account prior work. It is partly due to the complexity of operationalizing ACAP other than by using proxy variables such as R&D intensity (Lichtenthaler, 2009; Camisón & Forés, 2010). These types of measure have two main disadvantages. First, they remain one-dimensional whereas there is a great consensus considering ACAP as a multi-dimensional concept. An explanation lies on the facility of using such proxies that led many researchers to measure the outputs of ACAP and to perceive it from a uniquely organizational point of view (Volberda et al., 2010). As a result, other aspects have been overlooked and it appears really questionable that a single measure can cover the whole

concept. Second, measures based on proxies, such as indicators of R&D activity, can only be used for large companies. Indeed, for time and financial reasons, most SMEs do not have a specific R&D budget and do not follow patent registration policies.

Based on these shortcomings, the objective of this exploratory research is twofold. First, it consists in testing a multidimensional (four dimensions) and multileveled (individual and organizational) approach of ACAP through the development of a new measurement tool designed for SMEs as recommended by Fernhaber and Patel (2012). In this respect, we follow Cohen and Levinthal (1990) and integrate Volberda et al. (2010) advices in focusing mainly on an individual level of analysis, a perspective neglected in past research. Second, it tests empirically the dimensions' complementarity following the two main conceptualizations of absorptive capacity: ACAP as a unified construct and ACAP as a two-factor construct (Zahra and George, 2002), Potential and Realized Absorptive CAPacity (PACAP / RACAP).

The main contribution of this research is to propose a more fine-grained view of ACAP development in integrating multiple levels of analysis in a measurement scale, and mainly an individual one, that meets validity and reliability criteria. This individual focus in ACAP development is based on Cohen and Levinthal (1990) arguments that "an organization's absorptive capacity will depend on the absorptive capacities of its individual members". It constitutes a first step in trying to investigate more directly how an organization's absorptive capacity differs from that of its individual members. Moreover, our results direct our attention to the absence of complementarity between ACAP dimensions. It suggest that ACAP as a unified construct is characterized by four knowledge activities relying on different mechanisms and probably different antecedents.

The paper is organized as follow. First, a literature review discusses different ACAP definitions, past operationalizations and the importance of studying it at an individual level of analysis. Second, this paper presents a scale development section where the dimensions of ACAP and related themes in past research are presented allowing us to propose a specific conceptualization. Third, methodological aspects are introduced before presenting the results of this investigation and discussing them in a fourth section.

The concept of absorptive capacity

DEFINITION

Following Cohen and Levinthal's (1990) original definition presented earlier, ACAP has three dimensions: acquisition, assimilation and exploitation.

In 2002, Zahra and George proposed a reconceptualization of ACAP, defining it as "a set of organizational routines and processes by which firms acquire, assimilate, transform

and exploit knowledge to produce a dynamic organizational capability" (p. 186). This definition represents a departure from earlier studies through two aspects. First it includes a fourth dimension, transformation. It also combines the four individual dimensions into two supra-dimensions – Potential Absorptive CAPacity (PACAP as a firm's ability to acquire and assimilate new external knowledge) and Realized Absorptive CAPacity (RACAP as a firm's ability to transform and exploit this new knowledge).

More recently, ACAP has been defined as "a firm's ability to utilize externally held knowledge through three sequential processes: (1) recognizing and understanding potentially valuable new knowledge outside the firm through exploratory learning, (2) assimilating valuable new knowledge through transformative learning, and (3) using the assimilated knowledge to create new knowledge and commercial outputs through exploitative learning" (Lane et al., 2006, p. 856).

While we borrow some aspects to these definitions – the dynamic perspective from Zahra and George (2002) and the recognition theme from Lane et al. (2006) – we do not strictly adhere to any of those for two reasons. First, Zahra and George's (2002) definition does not take into account the ability to recognize and value new external information, an ability that is crucial to external knowledge acquisition. Second and opposed to Lane et al. (2006) and Todorova and Durisin (2007), the recognition that transformation is a distinct step between assimilation and exploitation is important. It highlights a knowledge conversion step before exploiting it. It also strengthens the dynamic capabilities perspective through the integration of organizational learning mechanisms based partly on transformative learning.

Consequently, we define ACAP as an embedded learning process that consists of four knowledge activities, that can be considered as dynamic capabilities: (1) acquisition based on recognition and valuation of new knowledge (it implies external and internal knowledge sharing mechanisms), (2) assimilation of this knowledge in the light of existing knowledge, (3) transformation of this knowledge by extending the firm's current knowledge base, and (4) exploitation of this knowledge to deliver high value knowledge and commercial outputs. This definition differentiates from past research as it both separates and encompasses four different knowledge activities that an individual – as well as an organization – would realize. At an individual level, it stresses the importance of knowledge sharing. It also highlights the relevance of social interactions in the context of this research (Zhao and Anand, 2009). Composed of four different knowledge activities, this definition questions the complementarity between ACAP dimensions.

PAST ACAP OPERATIONALIZATIONS

Operationalizing ACAP has proved a major problem for researchers. Despite twenty years of research, "most studies

have operationalized ACAP with R&D-related proxies, such as R&D intensity or patents [...] leading us to question whether these studies actually measured absorptive capacity at all” (Lane et al., 2006, pp. 854). There are three main limitations to the use of “objective” measures to study ACAP, which reinforce the relevance of this research.

First, proxy measures of ACAP have weak explanatory power compared with the complexity of the dimensions of the concept (Lichtenthaler, 2009). As proxies only measure one aspect of ACAP, a great majority of past studies are liable to attribute excessive importance to one dimension at the expense of the other dimensions – ACAP is not just about R&D intensity or number of patents. In addition, “knowledge-creation” proxy measures may lead to accuracy problems, and patents may reflect strategic positioning rather than real innovation (Spender and Grant, 1996).

Second, most ACAP measures were developed for large companies and are therefore totally inadequate for SMEs (Fernhaber and Patel, 2012). This is the case of most studies measuring ACAP by not using proxies (Szulanski, 1996; Jansen, Van Den Bosch & Volberda, 2005; Lichtenthaler, 2009). For example, because SMEs do not always have a specific R&D department, it can be difficult to assess the resources allocated to research activities. Patent registration is also frequently inapplicable, as many SMEs consider the patent process to be too expensive and time-consuming. What’s more, the absence of a R&D department or a patent registration policy does not mean that a firm does not acquire knowledge.

Third, a review of prior research into ACAP reveals major inconsistencies in the results of proxy-based studies. For example, some papers report that ACAP (R&D intensity) predicts interorganizational learning, whereas other studies found that it does not (Mowery, Oxley and Silverman, 1996; Tsai, 2001). Consequently, the suitability and validity of proxy measures for ACAP are highly empirically questionable.

A very small number of studies (Szulanski, 1996; Jansen et al., 2005; Flatten et al., 2011) have assessed ACAP using other kinds of variables, leading to the development of a measurement scale. Szulanski showed that a lack of absorptive capacity (a one-dimensional scale with 9 items) of the recipient is the first variable explaining internal stickiness, which prevents knowledge transfer. Jansen et al. (2005) found that organizations in dynamic environments improve their financial performance by increasing their PACAP (a two-dimensional scale with 9 items). Results for RACAP (a two-dimensional scale with 12 items) were more ambiguous. More critical is that the variables used in these studies account for a greater percentage of the variance than R&D intensity. Flatten et al. (2011) develop a reliable multidimensional measure of ACAP based on two surveys of German companies. These works constitute key references for this research. Thus, both past research shortcomings and

the promising results of the few studies that measure ACAP not by using proxies, lead to a necessary and valuable new approach of the concept.

THE IMPORTANCE OF STUDYING ACAP AT AN INDIVIDUAL LEVEL OF ANALYSIS

Given that our objective is to develop a new measurement tool of absorptive capacity, we believe that adopting a multilevel approach of the concept, with a focus on the individual, is an answer to five main issues.

First, although Cohen and Levinthal (1990) argued that organizational ACAP is a function of individuals’ absorptive capacities, it is rather surprising to note that no research has been conducted on an individual level. As Lane et al. (2006, p. 853) pointed out: “The lack of attention to the process aspects of absorptive capacity has also led researchers to overlook the role of individuals in developing, deploying, and maintaining absorptive capacity”. This is a major omission. This oversight must be rectified, as “individual cognition is a critical internal driver of absorptive capacity” (Lane et al., 2006, p. 857). In addition, academics emphasize the role of ACAP in promoting innovation and this aspect cannot be fully explored through a strictly organizational lens.

Second, Cohen and Levinthal (1990) believed ACAP to be an organizational level construct that resides in firms and organizational units. ACAP has been analyzed on country, interorganizational and organizational levels, but most studies have only considered it on an organizational level. As a result, they did not take into account the composition and the links of the different dimensions of ACAP (Zhao and Anand, 2009). It leads to consider it as a kind of supra concept, disconnected from practical learning strategies within firms.

Third, the richness of the concept and of the underlying dimensions cannot be included in proxy measures that are often one-dimensional. Moreover they do not really measure ACAP in our view, but more its outcomes (innovation, number of new products/services, projects initiated...) or maybe its antecedents (R&D investments...) (Flatten et al., 2011; Jiménez-Barrionuevo et al., 2011). Mainly adopting an individual approach of the concept enables to overcome this aspect in developing specific scales for the four dimensions that can reflect the different knowledge activities undertaken by individuals at each stage.

Fourth, as absorptive capacity has already been theoretically conceptualized as the capacity of individuals to acquire, assimilate, transform and exploit external knowledge flows, some academics (Mowery and Oxley, 1995; Veugelers, 1997; Mangematin and Nesta, 1999) have used measures related to firm’s human capital (number of scientists, doctorates, investments in training...). While these

metrics highlight the relevance of developing an individual perspective of ACAP research, they do not really measure the four knowledge activities that composed absorptive capacity.

Fifth, ACAP literature has not brought yet connections between the different levels of analysis to our knowledge. A direct consequence is that scholars do not refer exactly to the same concept when studying absorptive capacity. This aspects breaks the unity of this research domain.

Building on these shortcomings we now present the development of our measurement tool.

Scale development

This section is divided in two main parts. The first one deals with the themes related to ACAP and our conceptualization in this study. The second methodological one presents pretest, sample, data collection and constructs validation issues.

DIMENSIONS OF ACAP AND RELATED THEMES IN PAST RESEARCH

Based on our definition we consider that absorptive capacity is composed of four distinct dimensions. Before describing our conceptualization of the construct, we present the composition of these dimensions in past research in table 1.

While several studies discuss their content from a theoretical point of view, very few papers develop a scale of ACAP in building each dimension separately. Consequently, there is no empirical validity of the following themes and components. However, this table presents at least a global vision of the richness and different aspects of the concept. It also grounds some bridges between ACAP and organizational learning literature. It reinforces the belief that a single one-dimensional measure is not appropriate to measure absorptive capacity. Following the same idea, Flatten et al. (2011) propose a table gathering numerous overlaps and similarities of ACAP's dimensions with related research streams. However we differentiate from that research in adopting a more focused approach of ACAP.

TABLE 1
Composition of ACAP dimensions in past research

Dimensions	Components	Themes	Main authors
Acquisition	Prior knowledge	Knowledge repositories, experience of R&D department, last qualification	Szulanski (1996); Autio et al. (2000); Van Wijk et al. (2001); Zahra & George (2002)
	Prior investments	Risk tolerance, CEO support, R&D investments	Cohen & Levinthal (1990); Mowery et al. (1996); Kim (1998); Lahti & Beyerlein (2000); Zahra & George (2002)
	Commitment to acquiring, sharing knowledge	Recognizing value, speed and commitment	Cohen & Levinthal (1990); Zahra & George (2002); Jansen et al. (2005); Lane et al. (2006); Liao et al. (2007); Todorova & Durisin (2007); Lichtenthaler (2009); Flatten et al. (2011)
Assimilation	Knowledge understanding	Interpretation, formalization, comprehension	Cohen & Levinthal (1990); Dodgson (1993); Szulanski (1996); Lane & Lubatkin (1998); Bontis et al. (2002); Jansen et al. (2005); Matusik & Heeley (2005); Todorova & Durisin (2007); Lichtenthaler (2009)
Transformation	Knowledge conversion	Recodification, questioning	Szulanski (1996); Kim (1998); Gruenfeld et al. (2000); Collins & Smith (2006); Liao et al. (2007); Lichtenthaler (2009); Flatten et al. (2011)
	Knowledge internalization	Integration	Szulanski (1996); Bontis et al. (2002); Jansen et al. (2005); Lichtenthaler (2009); Flatten et al. (2011)
Exploitation	Knowledge use & implementation	Knowledge intensity, harvesting resources, core competencies	Cohen & Levinthal (1990); Dodgson (1993); Lane & Lubatkin (1998); Autio et al. (2000); Lane et al. (2006)

Flatten et al. (2011) propose a thorough perspective of all domains linked to ACAP studies in presenting 29 related research streams, referring for instance to collective mind, team knowledge, innovation capability or even market orientation. This approach that can be considered as really valuable in a literature review perspective appears somewhere unusable in a scale development attempt. Indeed, due to the complexity and multiple research streams linked to the composition of each dimension, it appears totally impossible to develop a measurement scale that encompasses all the different conceptions and contributions of the fields presented in their table. Moreover, they apply all these related domains to the dimensions level, making more complex the building of each ACAP factor. Indeed it includes numerous overlaps and sometimes inconsistencies between the themes referring to the same dimension. For instance, when considering assimilation, it appears really difficult to practically refer to all the 15 related research streams – collective mind, information processing, knowledge creation, knowledge dissemination, knowledge exchange, market orientation in terms of intelligence dissemination, organizational memory, etc... – to build items having a kind of unity for this single dimension. For these reasons we adopt a more narrowed approach of the concept referring partly to Lane et al., (2006) in proposing to focus on three main research fields having strong links with ACAP literature: organizational learning, strategic alliances and the knowledge-based view. It leads to practically consider about fifteen papers that may be useful in developing a pool of initial items.

Thus, based on this literature review and our qualitative study, we build a measurement scale that departs from previous research in combining individual-level variables with one organization-level variable, thereby testing a multidimensional and multileveled approach of ACAP. This part is voluntary descriptive as very few scales were developed operationalizing these four dimensions.

CONCEPTUALIZATION OF ACAP IN THE PRESENT STUDY

Our conceptualization is in line with our individual approach of the concept, based on the fact that ACAP measurement at the firm level has brought elusive results in past research. Indeed, it not only depends on R&D investments but also on several others firm and/or individual attributes, such as the existence or effectiveness of communication channels, of knowledge processes (Godfrey and Hill, 1995; Jansen et al., 2005). Taking into account the specificities of our sample (size, scarce internal resources, etc...) reinforces the importance of knowledge sharing mechanisms when designing our measurement scale.

Acquisition

The first dimension of absorptive capacity has been labeled acquisition. It refers to the process of recognition and valuation of new external knowledge (Cohen and Levinthal,

1990). Acquisition is thus the outcome of recognizing and valuing external knowledge. Therefore, this dimension is difficult to grasp as it consists in measuring the underlying processes of recognition and valuation and/or the outcomes of these processes (acquisition). Taking an individual approach to ACAP we specifically focus on the third sub-dimension of acquisition (commitment to acquiring, sharing knowledge; see Table 1). Indeed, related measures linked to the first two sub-dimensions (prior knowledge and prior investments) were conceptualized as proxies in past research articles. This focus on knowledge sharing mechanisms leads to consider that “an organization’s absorptive capacity does not simply depend on the organization’s direct interface with the external environment. It also depends on transfers of knowledge across and within subunits” (Cohen and Levinthal, 1990, p. 131). More precisely, the development of ACAP is dependent on knowledge sharing routines inside and outside the firm (Dyer and Singh, 1998). Therefore, what seems important to us in this dimension is the co-existence of external and internal aspects in knowledge acquisition. This perspective highlights the importance of knowledge sharing mechanisms that appear critical for SMEs’ managers.

Consequently, we follow two lines in building this dimension: recognition aspects (including risk propensity, a theme of knowledge acquisition) with the development of 6 items and the outcome of recognition and valuation activities through knowledge sharing aspects with 6 items. In opposition with Flatten et al. (2011), we prefer measuring the outcome of recognition and valuation activities than the role of management in acquiring new external knowledge through firm formal processes and requirements from management. These items intent to measure both knowledge recognition processes within the firm and the degree of knowledge access and flow related to changes concerning both internal (products and services, strategic orientation...) and external aspects (providers, suppliers, technology...). We draw our inspiration based on studies by Szulanski (1996), Zahra and George (2002), Lichtenthaler (2009) and Murovec and Prodan (2009).

Assimilation

“Assimilation refers to the firm’s routines and processes that allow it to analyze, process, interpret and understand information obtained from external sources” (Zahra and George, 2002, p. 189). Knowledge assimilation depends on the capacity of individuals to understand new external information and to link it to the existing knowledge base. An assimilation scale must measure the capacity of individuals to learn and understand new external knowledge, and to question existing processes and ways of doing. In the present study assimilation is considered merely as an external activity, so the items assess individuals’ understanding and interpretation of new knowledge based on knowledge confrontation between external and in-house actors. This perspective is very different from that of Flatten et al. (2011).

They conceptualized it as an internal activity through the role of structure and management in knowledge diffusion or the existence of IT tools that ease knowledge sharing. Opposed to their view, we follow Jansen et al. (2005) and Lichtenthaler (2009) in developing items that encompass activities of absorbing knowledge from external sources as it also better corresponds to the specificities of high-tech SMEs. Six items measure the discovering of new practices, technologies, actors, products and reconsideration of way of working, partially based on the work of Zahra and George (2002), Lichtenthaler (2009) and expert interviews.

Transformation

Transformation is a process of knowledge conversion through internalization of new external knowledge in a firm's existing processes and products (see Table 1). "Transformation denotes a firm's capability to develop and refine the routines that facilitate combining existing knowledge and the newly acquired and assimilated knowledge" (Zahra and George, 2002, p. 190). Szulanski's (1996) "retentive capacity" measure, defined as the "ability of a recipient to institutionalize the utilization of new knowledge" (p. 31), is partly included in the transformation dimension of Zahra and George (2002). Consequently, Szulanski's (1996) study was used as the basis for the transformation scale, which includes six items suggesting a change in existing knowledge and the integration of new one. There is a strong similarity with Flatten et al. (2011) on this dimension. Items assess the improvement of current methods and practices through new solutions, new ways of doing, the modification of old processes and the use of new tools (Lichtenthaler, 2009).

Exploitation

Cohen and Levinthal define exploitation as the ability of employees to apply new external knowledge to commercial ends. This dimension has probably been the most used one because ACAP was often operationalized through its outputs (innovation, patents...). In order to create a global ACAP scale that incorporates all four dimensions, it was necessary to set aside these measures in favor of criteria that give due weight to the performance of individuals' actions and perceptions. We consider that this dimension is an organizational one in essence. In fact, the efforts to improve and commercialize a product/service and to deliver it to the market represent collective activities that cannot be undertaken by a single individual. As the aim was to assess the benefits resulting from individuals' knowledge, it seemed reasonable to measure organizational outcomes (Spender & Grant, 1996a). We used the scale drawn up by Autio, Sapienza and Almeida (2000) to assess the degree of technology, knowledge and know-how contained in the firms' products and services. This variable highlights the contribution of the employees' knowledge to the production and commercialization of high-value products and services (see Table 1).

SCALE PRETEST AND REFINEMENT

We embark on exploratory qualitative research in order to generate new insights of the concept at an individual level of analysis. The goal was to assess the items and to pretest the relevance of the questionnaire. This work makes part of a larger study dealing with mechanisms for promoting innovation and organizational learning. It was carried out on behalf of regional institutions and associations interested in the development of high-tech SMEs. It allows us to substantiate the content of the concept (Miles and Huberman, 1994) and second to get feedback about how the items spanned the theoretical space (content validity). From one hand, we realized roundtables with SMEs' CEOs between the Club of Techno-Performing Enterprises (CETP) and regional institutions representatives. From the other hand, we seek reviews from professors and peers during doctoral workshops. Wording, theoretical consistency and managerial relevance were the main criteria for assessing an item during the two rounds of refinement. We also asked these persons to fill out the questionnaire in order to check out problems related to this operation.

Altogether, we collected data from a set of 28 CEOs, professors and doctoral students. It resulted in some changes in the building of our measurement scale during the different stages of scale pretest and refinement (Figure 1). From the first pre-test we deleted two items of the acquisition dimension. From the second one four items were removed from this dimension. These operations point out the sufficiency of acquisition that was reduced to ensure some unity in this learning activity, measuring only the outcome of knowledge recognition and valuation. Moreover, scales were refined to practically measure the content of each dimension. Some items were also rewritten to meet their requirements. Thus, an initial set of 27 items was summarized in 21 items to measure absorptive capacity. The 6 "recognition" items removed from the qualitative assessment are presented in Appendix.

SAMPLE

We choose to focus on small and medium-sized firms because, when compared to larger firms, SMEs have relatively fewer resources such as skilled employees, revenue, or assets which are critical to innovation. Therefore they need to develop their absorptive capacity to counterbalance this disadvantage (Liao et al. 2003). This is especially true in high-tech industries. Thus, thanks to the support of the CETP and some regional institutions at the origin of the project, the present research focused on a group of French high-tech SMEs that were active innovators. We follow Liao et al. (2003) who indicated that high-tech SMEs are adequate to study absorptive capacity because it is a key driver for their growth. Beyond this aspect firms were selected on three global criteria in order to provide a kind of unity for the firms composing our sample: size, revenue and technological performance criteria.

FIGURE 1
Evolution of number of items during stages of scale pretest and validation of constructs

	Items coming from literature	Pretest with managers	Pretest with professors and peers	Final scale
Acquisition	12	10 (2 items deleted)	6 (4 items deleted)	6
Assimilation	6	6	6	5 (1 item removed)
Transformation	6	6	6	4 (2 items removed)
Exploitation	3	3	3	3
	27 items	23 items	21 items	18 items

First, we chose firms having between 20 and 250 employees based on the European Union definition that is much closed to the OECD one concerning small and medium-sized firms. Thus we do not include very small firms, i.e. less than 20 employees.

Second, all the firms pertaining to our sample do not have a turnover greater than 50 Million Euros. Based on these two first criteria, 19 “Techno-Performing” firms were chosen from the sample of regional institutions that include more than 50 firms.

Third, firms were finally selected according to some of the technological performance criteria used by the OECD to determine a firm’s “degree” of technology: R&D investment, sales per employee, sales growth and patents. From an initial sample of 19 “Techno-Performing” firms, 10 were retained as complying with the chosen technological performance criteria. These SMEs cover several different high-tech industry sectors, including automatic control, robotics, electronics, computing and telecommunications. In all these industries that are research intensive sectors of the French economy ACAP is considered as critical. Using these three global criteria allow to control for important differences between these companies, differences that may have an impact on absorptive capacity.

DATA COLLECTION

Thanks to the support of the CEOs, a meeting was organized in each firm to present the main objectives of the research. Thus, we had access to a representative sample of employees of all 10 firms. Sampling was realized with the CEO of each firm, keeping in mind the idea to mainly question employees concerned with knowledge absorption. In this respect, we give priority to senior executives and

project/team managers within these 10 firms, all of them answering the questionnaire. The CEOs of these companies did not participate in this study for two reasons. First, they were part of the global regional project. Second, they participate in the pretest of this study consisting in roundtables to improve the questionnaire. Indeed, we consider CEO as a critical actor in terms of knowledge in their company and, for this reason, we prefer work with them in the questionnaire building and refinement than in the quantitative study. Moreover, the entire senior and project/team managers within these companies that have also a great knowledge of all their firms’ operations answer the questionnaire. These respondents were deemed to be the key decision makers in strategic, technological and market choices and qualified to speak about their firm’s operations.

At the time of the survey, eight firms out of the ten were less than 10 years old, while the two remaining companies were between 15 and 20 years old. In terms of size, nine firms had fewer than 100 employees, the remaining one employing between 150 and 200 people. In order to test the sample for informant bias, questionnaires were analyzed taking into account the hierarchical level of each respondent. Thus they have to indicate their position in their respective firm (senior executive, project/team manager, employees). From the final sample, 61 respondents were senior executives (financial, marketing, R&D directors for instance), 119 were project/team managers and 30 were employees, mainly responsible for administrative tasks (contracting, project assistance, logistics...). Analyses were realized by comparing responses coming from senior executives, project/team managers and from employees. No significant differences emerged between these three groups (individual items assessment display a narrow range) indicating that there was no bias. While we could expect some differences between the respondents, this result, putting

forward by CEOs, could be explained from the fact that all of them display multiple roles and participate in the different projects within the firm.

Respondents were highly qualified, 86 % having a university master diploma (or more i.e. a doctorate) in engineering sciences. The rest of the sample is lightly less qualified with a two-year post-baccalaureate degree. Concerning tenure (job experience) 33 % of employees have less than 2 years, 37 % between 2 and 5 years and 30 % more than 5 years. The majority of respondents are in their first or second job experience. Many of them were in the firm since its creation. In terms of experience within the firm, 32 % have less than 2 years, 27 % between 2 and 5 years and 41 % more than 5 years.

Following the recommendations made by Van den Bosch et al. (2002), questionnaires were sent by email to all the employees of the firms in the sample. Of the 246 questionnaires completed and returned by the employees, 36 had values missing and therefore had to be discarded (we excluded questionnaires having missing values in order to prevent from approximation bias), giving us a sample of 210 valid questionnaires. In order to ensure confidentiality, employees were asked to mail the questionnaire to us directly rather than sending it via their company's headquarters. All the items (description in Table 2) were measured on a seven-point Likert scale, ranging from 1 (strongly disagree) to 7 (totally agree). Finally, as the data were collected from a single informant and survey instrument, we applied the single-factor test to check for common method bias (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). This procedure based on principal components factor analyses indicated that several factors emerged. None of them accounted for the majority of the co-variance. It suggested that there was no problem coming from common method variance in our data.

VALIDATION OF CONSTRUCTS

The first step in this process was to check the reliability of our scales. Construct convergent validity and discriminant validity was assessed using exploratory and confirmatory factor analysis. Content reliability was checked during doctoral workshops and roundtables with SMEs' managers. The theoretical space of each concept, the structure of the questionnaire and the formulation of the items were analyzed taking into consideration both theoretical and managerial issues. This aspect provided preliminary support for the content validity of our ACAP scale. Discriminant validity was analyzed in four ways. First, cross-loadings values (the largest loading of an item on one of the three remaining factors) have to be negligible (values lower than 0.3 support it). Second, the model fit is assessed: low modification indices and standardized results suggest no changes in correlations or loadings, and thus confirm discriminant validity. Third, the average variance extracted

within factors was compared with the square of the bivariate correlations between factors (Fornell & Larcker, 1981). Fourth, to assess the discriminant validity of the measures a three-dimensional confirmatory factor analysis was also performed using AMOS (more details below).

When conducting multilevel studies, academics need to be explicit about how data collected at one level of analysis are related to constructs at a higher level of analysis. This aspect is quite clear for absorptive capacity as already mentioned. We follow the compilation aggregation principle for identifying the relationship between lower-level data and higher-level constructs. Thus we use simple descriptive statistics to represent the processes that associate lower-level data with higher-level constructs (Hitt, Beamish, Jackson and Mathieu, 2007). Another condition is that the level at which data are analyzed should be aligned with the level of theory for the constructs involved. However, we are in extreme circumstances with absorptive capacity in the way that there is a great consensus considering that ACAP emerges at the individual level while nearly all empirical studies to date are realized at the organizational level. Our individual approach of the concept lies in the decision that most dimensions are based on individual behaviors. Moreover, we do not aggregate the last factors as it reveals individuals' perceptions of knowledge firm intensity.

As little research on this concept has directly treated it this way, we attempt to integrate some of the critical issues surrounding multilevel phenomenon (Chan, 1998; Klein, Dansereau and Hall, 1994; Klein and Kozlowski, 2000). As Cohen and Levinthal (1990) point out absorptive capacity becomes a higher-level phenomenon through interactions between individuals and groups within the organization. In order to adopt a multilevel approach of this concept we follow Klein and Kozlowski (2000) compositional bottom-up process, which describes phenomenon that are mainly the same as processes emerge from lower to higher-level phenomenon. First, they argued that multi-level theories originate from the level at which the criteria are believed to reside. That's the positioning we adopt to study absorptive capacity. Indeed, absorptive capacity developed from the perceptions and cognitions of individual employees based on the processes and mechanisms that encourage knowledge absorption within the firm. Even if absorptive capacity has been conceptualized as an organizational variable, it takes its origin in individuals' actions, and it is through exposure to similar organizational practices and routines related to knowledge absorption that members develop a common assessment of absorptive capacity. Second, Klein and Kozlowski (2000) posited that theorists should articulate the level of predictor constructs and the processes by which higher-level constructs form and are related to the focal outcome(s) of interest. Demonstrating agreement across individuals within the same company regarding the development of absorptive capacity is a way to tackle level of analysis issues through a compositional bottom-up approach. In our view, absorptive capacity outcomes can

only be understood by a careful measurement of the sub-components of this concept at the level of individual actors. In this respect, the qualitative pre-test work helps identify and specify the processes and mechanisms by which absorptive capacity develop.

From a technical point of view, a multi-level analysis requires a separate and independent measurement for the higher level phenomena. We try to tackle with the problem of consistency between different levels through three ways. First, we measure the difference between respondents within the 10 firms of our sample through Levene and t-tests. Results show really weak differences between the ten organizations. Values for the Levene and the t-test are high what indicate that there are no significant differences between the respondents. Moreover the confidence interval displays the value 0, what confirms that the means difference is not significant. Moreover, it is important to indicate that differences are still weaker if we consider the assessment on every single organization. Second, we follow the recommendations for scale development from Churchill (1979) that partly takes into consideration this problem. Third, we employ in combination two data collection procedures in combining qualitative and quantitative surveys (Dansereau and Yammarino, 2005). It allows to limit the problem of compliance between multiple level of analysis.

Reliability and exploratory factor analysis was performed with SPSS. Reliability was assessed using exploratory factor analysis, which evaluates the fit of items in a scale and helps to identify factors of correlated items. The 21 items were subjected to a principle component analysis with varimax rotation (Table 2). Only items with a factor loading greater than 0.40 were retained in the analysis (below this threshold it does not well represent the underlying content). Cronbach's alpha was used as an internal consistency reliability indicator. This was followed by a confirmatory factor analysis using the AMOS software. By carrying out structural equation modeling after a principal component analysis, it is possible to assess the content of a questionnaire and to determine the best factorial structure in terms of adjustment to empirical data. In this perspective, we follow Gerbing and Anderson (1988) and Burton et al. (1998) who recommended that conducting a confirmatory factor analysis is necessary and the best way to establish the unidimensionality of the concepts understudy.

Therefore three different conceptualizations for testing complementarity between ACAP dimensions are tested (Becker, Klein & Wetzels, 2012): ACAP as a unified concept, i.e. a one-factor model, ACAP as a two-factor model referring to Zahra and George (2002) conceptualization: PACAP and RACAP and ACAP as four separate dimensions, i.e. a four-factor model. This procedure is all the more justified in our study for two reasons. First, the concept of ACAP is not stabled from a dimensionality perspective. Indeed, should we consider ACAP as a single four-factor model? Does the proposition of Zahra and George (2002) of a two-factor model with PACAP and RACAP is prefer-

able? Or, lastly, can we consider that the four underlying activities that are really different in nature constitute four single factors, not directly linked the one with the other? Second, Andrews et al. (2004, p. 115) indicated that they "specified the individual items used to assess each theme as manifest indicators of their respective first-order factors". We also find the same testing procedure in Lynch et al. (2010) who specified that all the analyses may be applied to the overall first-order factor and, in case, to the underlying dimensions. Our testing procedure tries to answer partly to this internal issue dealing with complementarity between the four dimensions.

Convergent validity was assessed using two complementary criteria: a significant t-statistic for each item level path ($t > 1.96$ and $p < 0.05$) and a path loading greater than twice the standard error (Fornell and Larcker, 1981). All four ACAP dimensions passed both convergent validity tests (Table 4). The quality and validity of the scales was checked using six adjustment indicators: χ^2/df , GFI, AGFI, SRMR, RMSEA and CFI. The χ^2/df is indicated but, as this measure is subject to sample size and items number effects, no major consideration should be given to it. Values of GFI and CFI greater than 0.90 and for AGFI greater than 0.80 indicate a good model fit (Pedhazur and Pedhazur Schmelkin, 1991). Considering the SRMR, values lower than 0.08 report an acceptable fit (Hu and Bentler, 1999). For the RMSEA, Browne and Cudeck (1993) indicate that values lower than 0.05 indicate a good fit, that values of 0.08 represent reasonable errors of approximation and that with values greater than 0.1 the model must be respecified. The results of the principal component analyses are presented first, followed by the results of the confirmatory factor analyses. Three different conceptualizations for analyzing ACAP dimensions' complementarity are tested: ACAP as a unified construct, ACAP as a two-factor model (Zahra and George, 2002) and ACAP as four separate dimensions.

Results

Table 2 lists the items for each dimension, together with the main results of the analyses. Internal consistency reliability indicators are presented, either for the four ACAP dimensions, the classic PACAP/RACAP model, or the global concept.

THE GLOBAL ACAP MODEL

The first analysis examined the global ACAP model. The results of the principal component analysis showed good reliability for the global ACAP scale. Extraction through a varimax rotation provided four factors that conformed to our expectations and to previous ACAP conceptualizations (Table 1). Total explained variance was also satisfactory. All items loaded significantly on four different factors, strongly corroborating the multidimensionality of the absorptive capacity concept (Table 2).

TABLE 2
Results of the principal component and reliability analyses

ACAP	M	SD	Factor loadings*				Cronbach's alpha		
			1	2	3	4	a	b	c
<Recipient> is informed about changes in products and services.	4.91	1.64	0.74				0.87	0.77	0.83
<Recipient> is informed about new strategic orientations.	4.44	1.87	0.77						
<Recipient> is informed about technological transformations and innovations.	4.94	1.75	0.72						
<Recipient> is informed about changes of partners.	5.20	1.47	0.85						
<Recipient> is informed about changes of suppliers or distributors.	4.47	1.83	0.77						
<Recipient> is informed about staff changes.	4.26	1.86	0.73				0.85	0.80	0.83
When meeting external actors: <Recipient> learns new management methods and processes.	3.66	1.77		0.65					
<Recipient> discovers new suppliers and distributors.	4.13	1.88		0.85					
<Recipient> acquires knowledge about external technical processes and technological innovations.	4.84	1.73		0.85					
<Recipient> discovers new products and services.	4.68	1.72		0.81					
<Recipient> has new ideas.	4.57	1.59		0.78			0.84	0.80	0.83
<Recipient> improves current methods and practices by proposing new solutions.	4.65	1.55			0.79				
<Recipient> improves current methods and practices by finding ways to go faster.	4.62	1.61			0.84				
<Recipient> improves current methods and practices by changing old processes.	4.91	1.69			0.77				
<Recipient> improves current methods and practices by using new tools.	4.99	1.65			0.79		0.85	0.80	0.83
We have a strong reputation for technological excellence.	5.36	1.60				0.91			
Knowledge intensity is characteristic of our business.	5.70	1.13				0.77			
There is a strong knowledge component in our products and services.	5.82	1.27				0.79			

Note: 1 = acquisition; 2 = assimilation; 3 = transformation; 4 = exploitation;

a = 4 dimensions; b = PACAP/RACAP; c = ACAP

* Only factor loadings greater than 0.3 are shown

A confirmatory factor analysis was conducted in order to investigate the global ACAP model and to examine the structural relationships between the four dimensions. It should be noted that a second order model could not be validated because of weak regression weights (< 0.5). It questions the

complementarity of the dimensions. In addition, although ACAP achieved a satisfactory Rho (0.85), the results of the confirmatory analysis were ambiguous. Satisfactory values were obtained for GFI and AGFI, but the RMSEA was not significant and the CFI value was weak (Table 3).

TABLE 3
Results of the confirmatory analyses for the global ACAP and the PACAP/RACAP models

Indicators	ACAP	PACAP	RACAP
χ^2/df	8.146	2.836	1.174
GFI	0.909	0.879	0.982
AGFI	0.815	0.787	0.902
SRMR	0.326	0.106	0.037
RMSEA	0.182	0.092	0.028
P	0.000	0.000	0.707
CFI	0.485	0.691	0.997
Reliability <i>Jöreskog's</i> ρ	0.849	0.096	0.498
AVE	0.59	0.05	0.33

THE PACAP/RACAP MODEL

The next step was to analyze the classic PACAP/RACAP model (Zahra and George, 2002), in order to determine its validity and to further investigate the relations between the four dimensions. Principal component analysis showed satisfactory results for both PACAP and RACAP. Cronbach's alphas for PACAP and RACAP indicated quite good internal reliability. Total explained variance was acceptable.

However, the confirmatory analyses were less positive. Although the results for RACAP were acceptable ($Rho = 0.50$), they were poor for PACAP, which gave a very weak Rho (0.10) and a non-significant RMSEA (Table 3). A second order model did not emerge. Therefore, the results for the PACAP and RACAP scales were ambiguous, questioning here the empirical suitability of this conceptualization.

As noted above, second-order models could not be validated because of weak regression weights. Taking into consideration this point it appears quite usual to check the reliability and unidimensionality of the underlying factors within a global model.

THE FOUR-DIMENSION MODEL OF ACAP

The scales are satisfactory with Cronbach's alphas for internal consistency indicating very good reliability for all dimensions (Table 2). However, when using a varimax rotation, two items of the transformation phase did not appear in the same dimension as the other four items. In addition, the rotated component matrix gave very different values for these two items compared with the others. Consequently, these two items were removed from the transformation

scale leaving four items to be considered in all analyses (see Appendix for the two deleted items). The total explained variance for each factor was also high.

The confirmatory analyses indicated that the scales for the ACAP dimensions are reliable (acquisition, $Rho = 0.89$; assimilation, $Rho = 0.89$; transformation, $Rho = 0.88$; exploitation, $Rho = 0.87$). All the statistical tests gave satisfactory results (Table 4).

Taking into account the results of the confirmatory analyses, it appears that the four-factor model is superior in comparison with the two other operationalizations. It calls into question in high-tech SMEs both the concept of ACAP as a unified construct, at least for measuring it, and the classic division of ACAP into two subsets.

Discussion and conclusion

As we have already indicated ACAP was conceptualized and operationalized in very different ways. It clearly prevents the comparison with most of prior works. However we try to take advantage of a few recent studies (Jansen et al. 2005; Lichtenthaler, 2009; Flatten et al. 2011) to test a multilevel and multidimensional scale of absorptive capacity (Jiménez-Barrionuevo et al., 2011), which constitutes a first attempt to our knowledge. Both this aspect and the context of high-tech SMEs make our results more indicative than conclusive, in the way that it raises as many questions as it brings definitive answers.

The main contribution of this study is to develop our understanding concerning absorptive capacity. Our results show that the use of multiple dimensions and levels of analysis is worth pursuing.

TABLE 4
Results of the confirmatory analyses for ACAP dimensions

Indicators	Absorptive Capacity Dimensions			
	Acquisition	Assimilation	Transformation	Exploitation
χ^2/df	1.312	0.906	2.855	2.086
GFI	0.983	0.985	0.993	0.994
AGFI	0.86	0.93	0.93	0.96
SRMR	0.040	0.029	0.018	0.013
RMSEA	0.038	0.000	0.093	0.071
P	0.543	0.785	0.177	0.253
CFI	0.989	1.000	0.995	0.996
Reliability <i>Jöreskog's ρ</i>	0.866	0.872	0.862	0.864
AVE	0.52	0.54	0.61	0.68

First, our scale, consisting in 18 items and 4 factors, satisfies recognized reliability and validity criteria. From a theoretical point of view, “the development and presentation of a four-factor measure of ACAP helps to ensure valid results and facilitates comparisons across studies” (Flatten et al. 2011, p. 111-112). From a managerial one a four-factor model can be much more precise in assessing knowledge activities within a company. It could also be helpful in determining the source of competitive advantage in comparison with past one-dimensional measures. Results also support our proposition of definition including the third dimension of transformation as a separate activity in opposition with Todorova and Durisin (2007).

Second, the previously neglected individual level may play an important role to understand ACAP global functioning in identifying precisely the nature of the mechanisms surrounding knowledge absorption dimensions. It could also serve to determine the mechanisms at play between the dimensions, several authors highlighting the potential role of personal networks of individuals.

Third, this research calls into question the two main conceptualizations of ACAP as a one-dimensional construct and as a two-factor model – Potential and Realized Absorptive Capacity (Zahra and George, 2002). As such, the classic division of ACAP into PACAP and RACAP is not justified – a conclusion that concurs partially with previous theoretical (Todorova and Durisin, 2007) and empirical (Jansen et al., 2005; Flatten et al. 2011) studies. In the opposite, this merger in two supra-dimensions appears valid according to two recent studies from Camisón and

Forés (2010) and Jimenez-Barrionuevo et al., (2011). Consequently, the internal structure of ACAP has to be further studied as pointed out by Volberda et al. (2010). However, we believe that by separating the four dimensions it is possible to determine the contribution of each to a firm's learning performance. It could allow the identification of specific mechanisms that may impede or facilitate each knowledge absorption step.

Finally, this research brings some new knowledge concerning the complementarity and the content of ACAP dimensions as was recommended by Lane et al. (2006). Results show that this study calls into question the complementarity of these four dimensions in a global one-dimensional model. It raises the question to consider it as a unified concept or as a multifaceted construct as Zahra and George (2002) first proposed. This consideration may help in determining the relative importance that the four different dimensions play in determining various organizational outcomes (managerial innovation VS product/service innovation for instance). This study develops our understanding of ACAP dimensions. Our knowledge-intensity measure (Autio et al., 2000) for exploitation more accurately reflects the dynamic nature of this dimension than previous measures, whether objective (R&D intensity, number of patents, etc) or empirical (Jansen et al., 2005). Compared to formal innovation variables (number of patents or product innovations, see for example Tortoriello & Krackhardt, 2010), which remain conventional metrics of individuals' innovation performance in management research, the managerial rating has the advantage of being applicable across all functions within firms, regardless of the nature and type

of innovation outcome expected. It provides more information and a more dynamic one than accepted static measure. It is also the case for assimilation that has been conceived as a knowledge confrontation activity with external actors. In opposition with Flatten et al. (2011) this perspective is interesting because it questions current vision of assimilation as an individual in-house activity. It also raises more direct ties with the dimensions of acquisition and transformation.

This scale could be a convenient tool for both academics and practitioners. For academics, it should ease theorizing and hypothesis building, for instance to identify determinants for each dimension. In this perspective, it may ease group constitution for practitioners through a better assessment of the required competencies at different stages of a project. Moreover, this multidimensional approach highlights the fact that implementing a learning strategy is a difficult process consisting in the combination of different activities, some external, others internal, some individual and others collective. Finally, our scale can be used as a diagnostic tool to identify areas where specific improvements are needed. Management can use the scale to create a basis for the development of effective learning strategies with a specific focus on individuals.

While our conceptualization and empirical findings are encouraging, this study has some limitations. First, we focused on high-tech SMEs while the major part of prior research has studied larger firms. From one hand, we recognize that individual mechanisms under studied in this research are sensitive to a number of firm-specific characteristics. From another hand, besides controlling for several aspects related to firm or respondents specificities, empirical studies based on individual data gathered from several firms offer the possibility to generalize the findings. But because several factors are absent in SMEs and that the impacts of some knowledge aspects such as diversity may greatly vary in comparison with large firms, we only cautiously generalize our findings. Second, our methodology presents a limitation in the way that appropriate sample size and two non-overlapping samples are necessary to develop a valid and reliable scale (Churchill, 1979). In this perspective, the generalizability of our scale is limited. Third, as very few studies proposed scales to assess ACAP, we had to develop difficult-to-measure constructs that could be improved. For instance, the acquisition scale does not take into account the “recognition” theme. Fourth, the four dimensions are not tested on a dependent variable. This may have reinforced the validity of our scale. It could be interesting for instance to test the impact of the four ACAP dimensions on performance, whether economic, social or technological.

First of all, future studies could try to replicate our scale in different research contexts in order to validate our multidimensional and multilevel approach. It also may lead to a scale refinement in including, for instance, other themes or sub-dimensions. Indeed, several ACAP scales were developed the last ten years (Jansen et al., 2005; Lichtenthaler,

2009; Flatten et al., 2011; and more...) and we believe it's now time to validate them instead on continuously developing new ones. Exploring the importance and the role of the four ACAP dimensions is also worth pursuing. The importance of these different knowledge activities may be contingent to some industry, firm or product characteristics. Thus, acquisition of new external knowledge may be more important in dynamic environments for instance. The role of these dimensions may also vary depending on the product life cycle. And finally they may also exert different impact on performance. Following this idea, researchers could explore the transitions between the different dimensions in investigating the role of complex relational mechanisms (coordination, knowledge transfer, etc...) that may facilitate ACAP development. This will allow to identify drivers related to each dimension and, hence, to better define their own perimeter and the global functioning of the concept.

Another fruitful avenue would be to identify ACAP dimensions' antecedents in mobilizing for instance social network variables. Indeed, to better explain the influence of relational aspects over ACAP, it could be interesting to pursue McFayden and Cannella (2004) research which suggests that the number of ties decreases knowledge creation, whereas ties strength displays the opposite effect. Thus, measuring the structural and relational impacts of employees' personal network over ACAP dimensions could help to better identify antecedents for each activity. It would enrich the debate concerning the pertinence of the PACAP / RACAP distinction.

Finally, we consider this research as a first step in the development of a multilevel of multidimensional ACAP scale. Our results seem to be promising and we hope it contributes to shed more light on the notion's content and relevance. It may facilitate the emergence of an approach considering ACAP as four distinct capabilities partly based on individuals, and not as a superior concept disconnected from its context.

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APPENDIX 1

The items removed from the initial version of the questionnaire

Acquisition dimension (items deleted from qualitative pretest)

Items for recognition:

<Recipient> discovers new ideas for my job during meetings, teamwork or just by wandering around.

<Recipient> gathers with my colleagues to share ideas and information without being forced by the organization or making part of a project.

<Recipient> gathers with my colleagues to solve problems without being forced by the organization or making part of a project.

<Recipient> knows my colleagues who hold a valuable experience within my firm.

Items for risk propensity:

<Recipient> has the possibility to work on new ideas.

If <Recipient> failed in creating something new, your firm encourages <Recipient> to go on.

Assimilation dimension (items deleted from quantitative analysis for cross-loading effects)

When meeting external actors: <Recipient> reconsiders the way of working.

Transformation dimension (items deleted from quantitative analysis for cross-loading effects)

<Recipient> improves current methods and practices writing notices from his/her work.

<Recipient> improves current methods and practices writing notices from projects he/she is involved in.

APPENDIX 2

The original version of the questionnaire

Acquisition

<Recipient> is informed about changes in products and services.

<Recipient> is informed about new strategic orientations.

<Recipient> is informed about technological transformations and innovations.

<Recipient> is informed about changes of partners.

<Recipient> is informed about changes of suppliers or distributors.

<Recipient> is informed about staff changes.

<Recipient> discovers new ideas for my job during meetings, teamwork or just by wandering around.

<Recipient> gathers with my colleagues to share ideas and information without being forced by the organization or making part of a project.

<Recipient> gathers with my colleagues to solve problems without being forced by the organization or making part of a project.

<Recipient> knows my colleagues who hold a valuable experience within my firm.

<Recipient> has the possibility to work on new ideas.

If <Recipient> failed in creating something new, your firm encourages <Recipient> to go on.

Assimilation

When meeting external actors:

<Recipient> learns new management methods and processes.

<Recipient> discovers new suppliers and distributors.

<Recipient> acquires knowledge about external technical processes and technological innovations.

<Recipient> reconsiders the way of working.

<Recipient> discovers new products and services.

<Recipient> has new ideas.

Transformation

<Recipient> improves current methods and practices by proposing new solutions.

<Recipient> improves current methods and practices by finding ways to go faster.

<Recipient> improves current methods and practices by changing old processes.

<Recipient> improves current methods and practices by using new tools.

<Recipient> improves current methods and practices writing notices from his/her work.

<Recipient> improves current methods and practices writing notices from projects he/she is involved in.

Exploitation

We have a strong reputation for technological excellence.

Knowledge intensity is characteristic of our business.

There is a strong knowledge component in our products and services.
