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Absorptive Capacity: Scale Development and Implications for Future Research

Vincent CHAUVET

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”. Following this definition and more recently the work of Zahra and George (2002) that built on it, 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 critical weaknesses is that no multilevel scale integrating the four dimensions was validated to measure ACAP (Wang & Ahmed, 2007; Flatten et al. 2011). Recent papers (Lane, Koka & Pathak, 2006; Todorova and Durisin, 2007) highlight the fact that past research do not to take into account prior work, 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 kinds of measure have two main disadvantages. First, they remain one-dimensional whereas there is a great consensus considering ACAP as a multidimensional 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, Foss & Lyles, 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 because, 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 research is twofold. First, it consists in developing a new measurement tool that encompasses multiple levels of analysis and four dimensions. Second, it empirically confronts then different conceptualizations of absorptive capacity. Our methodological approach is based on the recommendations for scale development from Churchill (1979), combining qualitative and quantitative methods thereby taking advantage of both methods. A literature review and a previous qualitative study enabled to define precisely the perimeter of ACAP dimensions, its internal functioning and to generate a first pool of items. A quantitative study allowed to test empirically our scale. 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 that meets validity and reliability criteria. Moreover, our results direct our attention to the complex internal structure of ACAP, composed of four different knowledge activities (internal/external, individual/organizational), that outlines some dynamic capabilities aspects and remains closely linked in a global learning sequence.

1. The concept of absorptive capacity

1.1 Definition of ACAP

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 in including a fourth dimension, transformation, and in combining 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).

We do not strictly adhere to any of the above definitions 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), the recognition that transformation is a distinct step between assimilation and exploitation is important because it highlights a knowledge conversion step before exploiting it and 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 was selected because it both differentiates and encompasses four different knowledge activities that an individual - as well as an organization - would realize.

1.2 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. 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, Van Den Bosch & Volberda, 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 three works constitute key references for this research even if our paper differs in some aspects. 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.

1.3 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 at all the composition and the links of the different dimensions of ACAP. It leads to consider ACAP 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 and that 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, to our knowledge, ACAP literature has not brought yet connections between the different levels of analysis. A direct consequence is that scholars do not refer exactly to the same concept when studying absorptive capacity, breaking the unity of this research domain.

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

2. Scale development

2.1 Dimensions of ACAP and related themes in past research

Based on our definition we consider that absorptive capacity is composed of four distinct dimensions which are discussed in the next section. Before describing our conceptualization of the construct, table 1 below presents the composition of ACAP dimensions in previous research.

Insert Table 1 about here

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 and 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. 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 which make more complex the building of each ACAP factor because of numerous overlaps and sometimes inconsistencies between the themes referring to the same dimension. For instance when considering the assimilation dimension 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 multilevel approach of ACAP. This part is

voluntary descriptive as very few scales were developed operationalizing these four dimensions.

2.2 Conceptualization of ACAP in the present study

Godfrey and Hill (1995) suggested that the measurement of some variables at the firm level has brought elusive results in management studies. They take the example of absorptive capacity arguing that it not only depends on R&D investments, but also on several others firm attributes, such as the existence or effectiveness of communication channels. Using intensively organizational learning literature we keep in mind the importance of communication channels and information processing in ACAP development in order to approach the different dimensions of the concept.

2.2.1 Acquisition

Acquisition describes the process referred to by Cohen and Levinthal (1990) as the recognition and valuing of new external knowledge. Taking an individual approach to ACAP highlights the importance of the close relationships created in rich social contexts (Tsai and Ghoshal, 1998; Hansen, 1999). These relationships improve communication between individuals (Verona, 1999) and enhance a unit's ability to acquire, assimilate and exploit knowledge (Jansen et al., 2005). Furthermore, "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). Similarly, the development of ACAP is dependent on knowledge sharing routines inside and outside the firm (Dyer and Singh, 1998). Knowledge acquisition can thus occur through

interactions with external units or with members of the firm. Therefore, what seems important to us in this dimension is the co-existence of external and internal aspects in knowledge acquisition. This perspective underlines the importance of information sharing which appear critical for SMEs' managers. Consequently, six items for the acquisition dimension were created in order to gather both knowledge sharing and motivational aspects (six items were removed from qualitative pretest, see appendix). These items measure the degree of knowledge access and flow, related to changes concerning both internal (products and services, strategic orientation...) and external aspects (providers, suppliers...). We draw our inspiration based on studies by Szulanski (1996), Zahra and George (2002), Jansen et al. (2005) and Murovec and Prodan (2009).

2.2.2 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. 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), Bontis et al. (2002) and Murovec and Prodan (2009).

2.2.3 Transformation

Transformation is the internalization of new external knowledge in a firm's existing processes and products. "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 knowledge. We also use Collins and Smith (2006) and Liao et al. (2007) works to build items assessing 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.

2.2.4 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 as R&D intensity, 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 individuals' actions and perceptions. Thus we believe that this dimension is an organizational one in essence because 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). Therefore, 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.

2.3 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 organizational learning that 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' managers 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 diverse set of 28 managers, 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

the same dimension. Indeed, these operations point out the sufficiency of acquisition that was reduced to ensure some unity in this learning activity. 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 items removed from the qualitative assessment of the questionnaire are presented in Appendix.

Insert Figure 1 about here

2.4 Sample

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. Firms were selected on three criteria in order to provide a kind of unity for the firms composing our sample. First, firms were chosen 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 industry sectors, including automatic control, robotics, electronics, computing and telecommunications. Second, based on the European Union definition that is much closed to the OECD one, firms pertaining to our sample have between 20 and 250 employees. Thus there are no very small firms, i.e. less than 20 employees. Third, all these firms do not have a turnover greater than 50 Million Euros. Using these three criteria allow to control for important differences between these companies, differences that may have an impact on absorptive capacity.

2.5 Data collection

The data collection process consists in a quantitative study to measure the reliability of our scale. Thanks to the support of senior management, a meeting was organized in each firm to present the main objectives of the research. Thus, we had access to all the employees of all 10 firms. The response rate is not indicated because it is not a relevant data taking into consideration the specific conditions of the research. The study was launched in January 2004 and all questionnaires were received by the end of March. Respondents were highly qualified, 86% having a university master diploma (or more i.e. a doctorate) in engineering sciences and holding positions of senior managers in their organization. The rest of the sample is composed by the administrative staff, slightly 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. 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, 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 to send 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).

2.6 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 three 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 & Larker, 1981). Finally, 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) which 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. 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 (SEM) 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 is the best way to establish the unidimensionality of the concepts under study. Therefore three different conceptualizations of ACAP are tested: 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 preferable? Or, lastly, can we consider that the four underlying activities that are really different in nature constitute four single factors? Our testing procedure tries to answer partly to this issue. Second, as noted on page 18, a second-order model 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. In this perspective 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.

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. 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.

3. 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.

Insert Table 2 about here

3.1 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, and extraction through a varimax rotation provided four factors that conformed to our expectations and to previous ACAP conceptualizations (Table 2). Total explained variance was also satisfactory. All items loaded significantly on four different factors, strongly corroborating the multidimensionality of the absorptive capacity concept.

A confirmatory factor analysis was conducted in order to investigate the ACAP measurement 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). Partly for this reason we also test others ACAP conceptualizations (a two-factor model referring to PACAP/ RACAP and a four-factor model). In addition, although ACAP achieved a satisfactory Rho (0.85), the results of the confirmatory analysis were ambiguous (Table 3). Satisfactory values were obtained for GFI and AGFI, but the RMSEA was not significant and the CFI value was weak.

Insert Table 3 about here

3.2 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, and the Cronbach's alphas for PACAP and RACAP indicated quite good internal reliability. Total explained variance was acceptable (Table 2). 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). Therefore, the results for the PACAP and RACAP scales were ambiguous.

3.1 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 subsequent 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, $Rho = 0.87$; assimilation, $Rho = 0.87$; transformation, $Rho = 0.86$; exploitation, $Rho = 0.86$). All the statistical tests gave satisfactory results (Table 4).

Insert Table 4 about here

The scales that measured the different dimensions of ACAP were satisfactory but some ambiguity was found for the PACAP/RACAP and the global ACAP models. These results call into question both the classic division of ACAP into two subsets and the concept of ACAP as a unified construct, at least for measuring it.

4. Discussion and conclusion

As we have already indicated ACAP was conceptualized and operationalized in very different ways which clearly prevents the comparison with prior studies. To our knowledge, this research is one of the first attempts to elaborate and test a multilevel and multidimensional scale of absorptive capacity (Jiménez-Barrionuevo et al., 2011). This aspect makes our results more indicative than conclusive, in the way that it raises as many questions as it brings definitive answers. Nevertheless, we believe it contributes to clarify some aspects in ACAP research and allows to compare ACAP conceptualizations in different studies as indicated by Flatten et al. (2011, p. 111/112): “The development and presentation of a four-factor measure of ACAP helps to ensure valid results and facilitates comparisons across studies”. As we consider this work as an important step in ACAP development, we will dedicate a paragraph in this section to compare and discuss the constructs and items of the present research with those of Flatten et al. (2011).

The main contribution of this study is to develop our understanding concerning absorptive capacity. Indeed, we explore it in testing different conceptualizations what offers new insights. First, our results show that the use of multiple level of analysis is worth pursuing. The previously neglected individual level may play an important role to understand ACAP global functioning. Moreover, we believe that including different levels of analysis in an ACAP scale offers a more fine-grained view of the external and internal mechanisms of knowledge absorption dimensions. Second, this research calls into question both the division of ACAP into two subsets (Zahra and George, 2002) and ACAP as a unified construct. Results show the relevance of examining ACAP in terms of four separate and complementary activities as this is the only way to integrate all the richness of the concept's dimensions. 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. Indeed this merger in two supra-dimensions is valid according to two recent studies from Camisón and Forés (2010) and Jimenez-Barrionuevo et al., (2011). This aspect has clearly to be further studied as pointed out by Volberda et al. (2010). However, we believe that by separating the dimensions it is possible to determine the contribution of each to a firm's learning performance, thereby allowing the identification of precise mechanisms that may impede or facilitate each knowledge absorption step. In addition, labeling one factor "potential" and the other "realized" implies a performance "trap" that may direct employees' efforts towards "exploitation" activities at the expense of "exploration" ones. Third, our scale, consisting in 19 items and 4 factors, satisfies recognized reliability and validity criteria and can be used in a wide variety of settings, even if it was designed for high-tech SMEs. Along these lines, this research brings some new knowledge concerning the content of ACAP dimensions. In an effort of taking advantage of past ACAP research we propose to compare our work with the one of Flatten et al. (2011) in order to draw up some connections and differences that may allow future studies on ACAP to take into account prior work as recommended by Lane et al., (2006). When building the acquisition dimension Flatten et al. (2011) highlight the role of management towards information issues through firm formal processes and motivational aspects. Our conception of this dimension is quite different as we put more emphasis on practical issues related to external and internal knowledge flows. Our items try to encompass different elements as the firm's direct interface with the environment, the resulting in-house knowledge transfers and the nature of changes that may affect employees' day-to-day work. Therefore we believe our scale better reflects the main themes related to acquisition even if the "knowledge identification" step does not appear clearly. Concerning assimilation Flatten et al. (2011) consider it as an internal activity, mainly

based on knowledge sharing and transfer perspectives through informal contacts and personnel exchanges. In our view focused on organizational learning literature, assimilation is conceived as an external activity based on knowledge confrontation with external actors. This aspect relies on the need of employees to come back to the knowledge source to assimilate new knowledge potentially distant from theirs. Our approach of assimilation presents two main advantages. First, it questions past vision of assimilation as an individual in-house activity and it raises more direct ties with the dimensions of acquisition and transformation. Second, it sets up some direct bridges with the organizational learning literature, a domain that we consider as the first nurturing field of ACAP, in discovering new methods, processes, tools and to put into question current firm's routines. For transformation there is a strong similarity with Flatten et al. (2011), our items consisting in the capacity of employees to absorb, use, link, transform and apply new knowledge. However our approach is more practically-oriented in the way that our items depict employees' improvements in terms of methods and practices through new solutions, new ways of doing, the use of new tools, etc... Lastly, Flatten et al. (2011) follow an innovation perspective when designing exploitation (new products/services, development of prototypes, patents, new technologies, etc...). This approach is interesting while it does not really figure out, in our view, the benefits resulting from individuals' knowledge which is one aspect that we consider as critical. Thus, our conception of exploitation, that is answer to both theoretical and empirical issues, is organizational and focused on the contribution of the employees' knowledge to the production and commercialization of high-value products and services. This measure relies on the idea that firms focusing on knowledge issues are more able to develop learning competencies that remain highly valuable when tackling with collective exploitation perspectives, i.e delivering products/services to the market. The advantage of such a measure is notably to take into account the nature of knowledge - tacit/explicit - without trying to figure out a difference in

the phrasing of the items between these types of knowledge. Moreover, this knowledge-intensity measure (Autio et al., 2000) 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). Finally and opposed to Todorova and Durisin's (2007) conceptualization, this study suggests that transformation constitutes an effective dimension of ACAP as our analyses clearly separate these items from the three other factors. This result is interesting as it corresponds to our prior theoretical conception of ACAP when comparing to some organizational learning models.

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 antecedents for each dimension. For practitioners it appears critical that it could be used on both individual and organizational levels. 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, 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 sufficiently take into account the "recognition" theme. Moreover, some of the results may be considered as critical as we accept RMSEA superior to 0.08 (transformation). Second, all the questionnaires were analyzed together without taking into account individual

differences between respondents or between participating firms: differences that could impact ACAP development. However, it is important to notice that several tests were handled to check that there is no significant difference between the respondents' answers. Third, starting from a theoretical basis to create our scale, we then turned to a data-driven method concerning items' selection. Thus, our scale does not perfectly reflect our theoretical positioning through ACAP definition. Fourth, the four dimensions are not tested on a dependent variable which could 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.

Apart from building a stronger scale including more themes, we believe that future research may focus on investigating the external and internal mechanisms impacting ACAP development. Because this study had not validated ACAP as a second order model, it could be interesting to consider it as a product of some algebraic combination between its dimensions. Thus, our proposition would be to test ACAP as a time-sequenced chain of learning processes characterized by a complex chronology involving a first and a last phase, and with backward and forward learning loops. This perspective assumes ACAP as a process composed of different knowledge activities and is fully compatible with the dynamic capability view of ACAP, under which the success of each phase relies on the efforts made in the previous step. These sequences would be characterized by the transition from an individual to a collective activity and from an internal to an external process. Another fruitful avenue would be to identify ACAP antecedents 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 and would enrich the debate concerning the pertinence of the PACAP / RACAP distinction. A last avenue would be to 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 researchers to identify drivers related to each dimension and, hence, to better define their own perimeter and the global functioning of the concept.

Finally, we consider this research as a first step in the development of an ACAP scale. Our results seem to be promising and we hope it contributes to shed more light on the notion's content and relevance, thereby facilitating 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: 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.

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.