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SMEs embedded in Collaborative Innovation Networks: How to measure their absorptive capacity?

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Response to Reviewers:	Response letter Dear Editor, Thank you for giving us the opportunity to revise our paper TFS_2019_1680_R1 entitled "SMEs embedded in Collaborative Innovation Networks: How to measure their absorptive capacity according to their context?". We are happy that you and the reviewers found value in our article and we thank you for your considerable efforts to help improve it. In the present letter, we reply to the suggestions received for minor modifications and indicate the subsequent alterations made in the revised manuscript. These modifications are also highlighted in the manuscript in red. After addressing the issues raised, we feel that the paper is more consistent and we hope you agree. The authors --- Response to Reviewer 1 Reviewer #1: Great improvement but reader still gets the impression that you neglect relevant TFSC literature. In your literature review, for example, I would discuss: Anja Leckel, et al, "Local Open Innovation: A means for public policy to increase

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SMEs embedded in collaborative innovation networks: How to measure their absorptive capacity ?

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Declarations of interest: none

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Abstract

SMEs increasingly participate in collaborative innovation networks (CINs), enabling them to access valuable external knowledge from other actors while maintaining high levels of internal competencies. The SME absorbs this knowledge to achieve reciprocal learning through its contribution to the common CIN goals, and one-way learning to improve its own organization's performance. This knowledge absorption varies according to the SME's context, described with factors such as the turbulence of its external environment, the motivations to contribute to the CIN, or the cognitive distance separating it from the network actors. To better guide this knowledge absorption, this research uses a two-stage mixed method to propose a contextualized operational measure of absorptive capacity (ACAP) for an SME embedded in a CIN. A qualitative phase consisting of semi-structured interviews was implemented first and enabled characterizing the SME's ACAP through a set of practices and dimensions that it could implement. Then a quantitative phase using the partial least squares (PLS) method established a model predicting the absorption dimensions and practices that the SME should master primarily according to its context in the CIN. Hence, this study provides SMEs with an instrument to assess their strengths and weaknesses with regard to ACAP in CINs.

Keywords

SME, Collaborative network, Open innovation, Absorptive capacity, Inter-organizational learning, Partial least squares

1. Introduction

SMEs possess significant potential for innovation thanks to their organizational agility and their proximity to the market (Sáez-Martínez et al., 2014). Nevertheless, innovation also requires the combining of diversified and highly specific knowledge that is rarely available within SMEs (Bougrain and Haudeville, 2002). In fact, these organizations tend to specialize in order to maintain a competitive market position (Narula, 2004). Consequently, they adopt open innovation alternatives to access complementary knowledge and improve their innovation capabilities (Spithoven et al., 2013). More particularly, SMEs join collaborative innovation networks (CINs) (Van de Vrande et al., 2009) involving heterogeneous actors, who work together in a climate of trust and intensive exchange in

order to achieve a mutually beneficial innovation goal within a limited period of time (Graça and Camarinha-Matos, 2017). Indeed, a recent report by the European commission (European commission, 2017) shows that 49% of SMEs innovate through collaboration with other partners, which explains European policy efforts to propose incentives promoting collaborative innovation by SMEs. These ad-hoc networks enable SMEs to pool their resources with other actors, share the risks and benefits inherent in the innovation development (Lee et al., 2010), and access external complementary knowledge for innovation provided by these actors (Van de Vrande et al. 2009).

To make efficient use of such externally accessible knowledge for innovation purposes, companies need to deploy their absorptive capacity (ACAP) (Zahra and George, 2002), which is very sensitive to the context of each organization (Lane and Lubatkin, 1998). ACAP is a multidimensional learning capability that reflects the organization's ability to acquire, assimilate and apply new knowledge to commercial ends (Cohen and Levinthal, 1990). Firms need to be aware of knowledge absorption modes in order to foster the success of their innovation strategies (Saad et al., 2017). Accordingly, several authors have proposed operationalizations of this concept to guide knowledge absorption by organizations that are engaged in innovation developments in intra-organizational (Flatten et al., 2011; Jansen et al., 2005; Ter Wal et al., 2011) but also inter-organizational contexts of innovation (Jimenez-Barrionuevo et al., 2011; Lane et al., 2001; Thuc Anh et al., 2006).

However, no prior research provides an ACAP operationalization that is adapted to the context of an SME embedded in a CIN. This gap cannot be covered by the transposition of the existing operational measures to an SME in a CIN for several reasons. First, intra-organizational operationalizations cannot be mobilized because an organization's ACAP in an alliance context is subject to the characteristics of its partners, such as their organizational structures and their commercial orientations (Lane and Lubatkin, 1998). Second, most of the existing inter-organizational operationalizations are proposed for long-term alliances, making them inadequate for actors embedded in ad-hoc collaboration networks. In fact, these actors absorb knowledge primarily to contribute to the achievement of an innovation goal within a limited period of time (Najafi Tavani et al., 2018); while in long-term alliances, the partners' ACAPs support the continuous development of capabilities that each of them uses to sustain his competitive position (Lubatkin et al., 2001). Therefore, the challenges of firms embedded in CINs regarding knowledge absorption and the creation of new capabilities and future business opportunities are markedly different from those faced by the actors pursuing operational efficiency in stable longer-term alliances (Valkokari and Helander, 2007). Finally, the few ACAP operational measures used in studies of collaborative inter-organizational contexts focus on large firms (Nieto and Santamaria, 2007; Jayaram and Pathak, 2013), and are therefore not suitable to SMEs embedded in CINs. Indeed, due to their limited systems and financial resources for gathering vital information on potential collaborators, SMEs tend to use professional intelligence processes for scanning and monitoring their technological

environments in a less intensive, structured and systematic way than big companies (Lee et al., 2010). Also, they usually do not collaborate with other partners under IP and power conditions that are similar to large firms (Spithoven et al., 2013).

Hence, knowing that ACAP depends on the organization's context and should be operationalized accordingly (Lane et al., 2006), this research aims to propose an operationalization of the ACAP adapted to the context of an SME embedded in a CIN. Previous studies underlined a variety of factors characterizing this context which are likely to induce variance regarding this SME's ACAP. For instance, this capacity is subject to the influence of "external activators" related to the turbulence of the external environment, "internal activators" reflecting the internal conditions that would compel an organization to absorb external knowledge (Zahra and George, 2002), "relative prior conditions" that describe the firm's similarities and differences regarding the other network actors in terms of organizational structures and commercial orientations (Lubatkin et al., 2001) and finally, "central roles" which correspond to the level of the organization's centrality within the network (Tsai, 2001). Therefore, a challenge is to propose an operationalization of the ACAP for an SME embedded in a CIN which takes into consideration the different factors describing its context. As such, the following question is raised: *How can we provide an SME with an operational measure of its ACAP considering its context within a CIN?*

To address this question, we adopted a mixed-method approach (Venkatesh et al., 2013), comprising a qualitative phase followed by a quantitative phase. The first, consisting of a thorough literature review and semi-structured interviews with SMEs and their partners within CINs, provided a better understanding of both ACAP practices for such an SME and the factors describing its context. The second, quantitative phase, aimed to generalize the qualitative results and formulate prediction equations that establish an order of priority for the absorption dimensions and practices according to the SME's context. Hence, the ACAP operationalization resulting from this mixed methodology requires the characterization of the SME's context based on the factors impacting ACAP. Accordingly, the prediction equations determine the most critical absorption dimensions and practices for the SME to master and in regard to which it would measure its ACAP. This article is organized as follows: first, section 2 is devoted to the development of our theoretical framework; then, section 3 explains the different steps of our mixed methodological approach; our results are introduced in section 4; finally, this article concludes with a discussion of its main contributions, limitations and avenues for future work.

2. Theoretical background

2.1. CINs for SMEs' open innovation

To keep a stable position in the market, SMEs try to maintain a sufficiently high level of internal competencies in only a few or even a single technological area (Narula, 2004). Consequently, to improve their innovativeness, SMEs rely on open innovation alternatives (Lee et al., 2010) enabling them to reap the benefits of their external environment and update their learning (Saad et al., 2017). While SMEs may adopt different open innovation strategies (Van de Vrande et al., 2009), a large number of studies indicate that collaborating with other organizations for innovation is a key alternative for SMEs (Edwards et al., 2005) even more than for large firms (Leckel et al., 2020; Wright and Dana, 2003). In this respect, SMEs join collaborative innovation networks (CINs) made up of "*a variety of entities (e.g. organizations and people) that are largely autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, social capital and goals, but that collaborate to better achieve common or compatible goals, thus jointly generating value*" (Camarinha-Matos et al., 2009:49). These networks represent symbiotic collaboration between two or more firms to improve the value of the output by reducing cost and time to market and enhancing the customer service to the benefit of all involved parties (Etemad et al., 2001). The actors learn together through mutual sharing of knowledge, and exploit jointly created innovation that makes them interdependent (Etemad et al., 2001; Lubatkin et al., 2001).

CINs have increasingly attracted both researchers' and practitioners' attention as an appropriate solution to overcome the difficulty for an individual company of developing innovations with sustained benefits (Najafi Tavani et al., 2018). In this regard, several scholars have examined the role of different network characteristics (power, size, centrality, structural holes and network density) in the development of firms' learning and innovation through CINs (La Rocca et al., 2016). Other researchers have investigated how collaborating with different external actors such as suppliers, customers, competitors, and research organizations results in expansion of a firm's existing knowledge base and advances its innovation capability (Clauss and Kesting, 2017; Kafouros et al., 2020). For SMEs, prior studies underline that these firms can develop various forms of collaborative innovation arrangements (Leckel et al., 2020). Much of the academic literature has investigated innovation networks solely involving SMEs (Corso et al., 2003). These collaborative configurations enable the SMEs to pool their resources and share the innovation risks and benefits (Lee et al., 2010) while maintaining their independence and implementing their own decision- making processes as part of the network (Valkokari and Helander, 2007). SMEs can also collaborate with large firms in dyadic buyer-supplier relationships according to a white box configuration where the supplier is responsible for manufacturing activities based on buyer specifications (Le Dain and Merminod, 2014). In fact, by supplying a portion of the high-volume needs of bigger firms, small firms can specialize more and

become more competitive by capturing scale economies not possible without large-firm linkups (Etemad et al., 2001). Furthermore, SMEs may develop horizontal collaboration with large firms to enhance their competitiveness. This collaboration can support their internationalization activities by enabling them to fuse elements of international business with entrepreneurship (Dana et al., 2008). Other researchers additionally underline that SMEs can develop university-industry collaboration to carry out an innovation process. Collaborating with research institutions enables SMEs to complement their often limited internal research resources (Teirlinck and Spithoven, 2008), obtain tangible R&D outcomes (Gkypali et al., 2018), and optimize their learning (Bjerregaard, 2009).

All of these CIN arrangements enable SMEs to access external knowledge provided by the other network actors to achieve a mutually beneficial innovation goal (Van de Vrande et al., 2009). To make efficient use of new external knowledge accessible through these networks, firms need to deploy their absorptive capacity (ACAP) (Kafouros et al., 2020; Najafi Tavani et al., 2018), a multidimensional learning capability introduced hereafter.

2.2. Absorptive capacity of SMEs embedded in CINs

2.2.1. ACAP, a multidimensional learning capability

ACAP embodies a dynamic learning capability that enables organizations to improve their innovation performance (Vlačić et al., 2019) and achieve a potential competitive advantage (Fosfuri and Tribo, 2008) through consistent knowledge utilization. In this regard, organizations implement a set of practices which are structured according to distinct dimensions, each one playing a different yet complementary role (Saad et al., 2017; Zahra and George, 2002).

First, **acquisition** reflects the organization's ability to identify and access external knowledge that is potentially useful to its operations (Saad et al., 2017). It includes mastering exploration techniques and relying on interpersonal skills to source valuable knowledge from external experts (Gkypali et al., 2018; Jimenez-Barrionuevo et al., 2011). Then, **assimilation** refers to the analysis of externally acquired knowledge to assess its potential (Szulanski, 1996). It involves activities of interpretation and confrontation between new knowledge and the organization's prior knowledge (Zahra and George, 2002), and communication skills to effectively disseminate new knowledge (Camison and Forès, 2010) and extend learning to an organizational level (Saad et al., 2017). Finally, **application** or exploitation represents the mechanisms enabling organizations to leverage existing competencies and create new ones by incorporating acquired knowledge into their operations (Cohen and Levinthal, 1990). It involves retrieving knowledge that has already been created and internalized for effective use (Lyles and Schwenk, 1992). Therefore, application first requires the internalization of new knowledge by combining it with the organization's prior knowledge in order to achieve a new integrative schema

(Cohen and Levinthal, 1990). To emphasize the importance of this integration, Zahra and George (2002) separate it from the effective application of new knowledge by proposing the dimension of transformation. However, although it is an essential prerequisite for exploitation that aims to prepare knowledge for its ultimate use, Schmidt (2005:3) states that *"the transformation dimension need not be made explicit, as it is an integral part of the exploitation component"*. Hence, to make efficient use of external knowledge throughout its contribution to a CIN, an SME would implement acquisition, assimilation and application practices.

2.2.2. Two learning perspectives for an SME embedded in a CIN

Through its contribution to the CIN, an SME accesses valuable external knowledge which can be absorbed to serve two learning perspectives (Inkpen and Tsang, 2008): **reciprocal** learning representing the organization's ability to combine this external knowledge with its own in order to contribute to the network's common goal (Lubatkin et al., 2001), and **one-way** learning reflecting the organization's ability to absorb external knowledge accessible through the network to accomplish individual goals (Khanna et al., 1998; Lane and Lubatkin, 1998).

In fact, while the primary purpose of organizations that engage in collaborative relationships is to jointly exploit their capabilities so as to develop products or services that none of the actors could achieve individually (Camarinha-Matos et al., 2009), Khanna et al. (1998) and Das and Teng (2000) point out that one-way learning might also occur. Although this learning is likely to provoke a race (Hamel, 1991; Larsson et al., 1998) and induce predatory behaviour in the partners through knowledge retention (Arino and de la Torre, 1998), several authors suggest that even in the logic of mutual benefit, a balanced cooperation and learning race would be an important source of competitive advantage (Argote and Ingram, 2000; Romer, 1990; Zaheer et al., 2010). Also, when a firm intentionally seeks to source and internalize knowledge from the other network actors, its benefits in terms of innovation come at a higher rate (Srivastava et. al, 2015).

Therefore, we endorse the propositions of these authors and suggest that an SME embedded in a CIN would implement acquisition, assimilation and application practices to serve both reciprocal and one-way learnings. In addition, the exploration by the SME of the valuable knowledge derived from the other partners of the CIN to improve its own performance can be pursued as the latter exploits its knowledge to contribute to the network innovation goal (Lee and Huang, 2012). Hence, we advocate that both learning perspectives occur simultaneously (see Figure 1).

2.2.3. Two distinct phases of knowledge absorption by the SME to contribute to the CIN

The literature highlights the fact that knowledge absorption differs according to the stages of an innovation process (Barbaroux et al., 2016). In the case of collaborative innovation, two main phases requiring different knowledge management and decision-making practices (Hacklin et al., 2006) are distinguished. The first one, called the setting-up or creation stage, includes aspects of idea formalization and network structuring. During this early phase, events such as trade fairs and conferences are a crucial knowledge source to gain inspiration for the innovative idea (Van Egeraat et al., 2013) and identify potential partners (Maskell et al., 2006).

The second phase, the operation stage, is focused on the way the partners will jointly mobilize their competencies to match the market opportunities (Camarinha-Matos et al., 2009; Graça and Camarinha-Matos, 2017). It is related to the development and commercialization of the innovation and requires for instance an intensive use of boundary objects to facilitate integration of knowledge created by the contributing actors (Mäenpää et al., 2016). Hence, to absorb knowledge for reciprocal learning and accordingly contribute to a collaborative innovation process, an SME would implement acquisition, assimilation and application practices differently within the two CIN phases.

2.3. Characterization of an SME's context within a CIN

Following an in-depth literature review, we hereby introduce the different factors describing the context of an organization embedded in a CIN, which are likely to impact its ACAP.

- *External activators*

They reflect uncertain environmental conditions that drive an organization to intensively activate its ACAP (Zahra and George, 2002). Some of these external activators come from a technological evolution or a high frequency of innovation that can influence the future of the industry in which the organization operates (Bower and Christensen, 1995). In addition, Lane et al. (2006) highlight other external activators that may lead to a more intensive ACAP, including frequent changes in market trends, as well as high levels of competitiveness and regulation (Glazer and Weiss, 1993). Therefore, the more the SME is subject to such external activators, the more it needs to develop its ACAP in order to adjust to turbulence in its environment (Liao et al., 2003).

- *Internal activators*

Several internal conditions can also make an organization more motivated to acquire and integrate new external knowledge (Gluch et al., 2009). Indeed, the organization deploys an intensive ACAP in order to achieve specific performance objectives (Fosfuri and Tribo, 2008), enabling it to recover for example from an organizational crisis (Cooper and Molla, 2012) or from successive performance failures (Matthyssens et al., 2005). Accordingly, the organization is motivated to absorb knowledge in

order to initiate deep changes that redefine its strategy (Zahra and George, 2002). It is also willing to absorb knowledge through an alliance in order to strengthen its financial, social and technological capitals (Ahuja, 2000). Additionally, ACAP evolution and development is dependent on the organization's human capital (Zahra and George, 2002). This suggests that a lack of employees' technological and other skills motivates the organization to deploy its ACAP in order to complement its knowledge base (Cohen and Levinthal, 1990). Thus, the more an SME participates in the partnership to address these specific challenges, the more it needs to develop its ACAP (McAdam et al., 2010).

- *Relative prior conditions*

In the case of an organization embedded in a partnership context, the literature suggests that several characteristics of its relationships with the other actors represent prior conditions impacting its reciprocal and one-way learnings, and consequently its ACAP in such context. Previous studies showed that these relational characteristics could be defined as a function of similarities or of differences. First, the similarity of the actors' knowledge bases fosters their reciprocal (Lubatkin et al., 2001) and one-way learnings (Lane and Lubatkin, 1998), as this knowledge proximity allows a mutual appreciation of their specific know-how. Also, ACAPs for both types of learning are better served by the similarity of the actors' institutional values and routines, as this organizational fit enables learning and reduces the possible cultural clashes or other interfirm conflicts (Arino and de la Torre, 1998; Lubatkin et al., 2001). Third, the expertise of each actor must be rooted in a different informational domain (i.e. area of expertise or know-about), since redundancy would limit the benefits of the partnership for both types of learning and increase the risk of opportunism (Lubatkin et al., 2001; Mendi et al., 2020). Finally, reciprocal learning is fostered when the actors have distinct commercial objectives, as they need to collaborate in order to discover how each of them can meet their own business goals without invading the other actors' markets (Lubatkin et al., 2001). On the contrary, one-way learning is encouraged by the similarity of the actors' commercial objectives, which allows a 'learning' organization to easily find commercial applications of newly acquired knowledge from its 'teacher' partner (Lane and Lubatkin, 1998). However, the facilitating effect of this factor mainly exists when the inter-organizational relationship is intentionally established to support one-way learning, such as franchises and joint ventures (Lane and Lubatkin, 1998). In alliances that primarily serve cooperative objectives, the similarity between the commercial orientations of the actors would rather inhibit the one-way learning of the organization, since the latter would direct its efforts towards managing and anticipating the risks of this coopetition situation (Fernandez et al., 2014). Hence, the less these related prior conditions are available, the more the SME has to develop its ACAP.

- *Central roles*

Tsai (2001) argues that units with central roles in innovation networks can use new knowledge efficiently only if they deploy relevant ACAP. Indeed, powerful actors are generally efficient

exploiters of new knowledge (Hill and Rothaermel, 2003; Lawrence et al., 2005), mainly since they intensively deploy their ACAPs to make good use of knowledge available through their privileged positions (Todorova and Durisin, 2007). In a collaborative network, an actor's level of centrality is described according to different factors (Goduscheit, 2014). It depends on the organization's implication in the innovation intellectual property (IP) which grants it with a champion role, and on its strong involvement in project management, technical coordination, and interfacing with the market. Consequently, the more fundamental is an SME's role in a CIN, the more it needs to develop its ACAP.

In sum, the contextual factors resulting from our literature review represent determinants of ACAP that are not controlled by an organization embedded in a CIN. Previous studies suggest that each of these determinant factors leads to a more intensive ACAP but provide little knowledge of how they impact the ACAP dimensions. Thus, this research aims first to explore the effects of these factors on each of the ACAP dimensions of an SME embedded in a CIN to explain how they are related. Moreover, a determinant represents a causal factor, whose variations are followed systematically by variations in an outcome of interest (Bauman et al., 2002). Hence, in addition to inducing a globally more intensive ACAP, the presence of these determinants would differentiate the way an SME absorbs knowledge within a CIN. Consequently, we propose to identify the variations of an SME's ACAP according to the factors describing its context. This would enable us to generate an ACAP operationalization which emphasizes the absorption dimensions and practices that the SME should master in priority according to its context. The implications of this state-of-the art are summarized in Figure 1, which constitutes our conceptual model. In our model, we have not considered the effect of central roles on one-way learning as this contextual factor only acts at the CIN level.

Figure 1 – Conceptual model

3. Research methodology

To achieve the objectives of this study, we followed a mixed-method approach, summarized in Table 1 and explained hereafter. Accordingly, this study adheres to comprehensive research capable of handling the qualitative-quantitative dilemma to analyze the actors and their actions in managerial situations (Dana and Dumez, 2015). More particularly, the present comprehensive research aims to highlight the mechanisms underlying observed phenomena (*ibid.*). In our case, these mechanisms relate to the absorption dynamisms of an SME to enhance its innovativeness according to its involvement context in a CIN. Our unit of analysis is thus an SME embedded in a CIN.

Table 1 – Research design

3.1. A qualitative phase to develop measurement scales for the model's constructs

Although there is no existing measure for ACAP in a CIN context, we decided to perform an in-depth review of the existing ACAP multidimensional scales (Appendix A) to reap the benefits of this literature corpus for our research. From the practices proposed in previous studies, we selected an initial pool of 54 items that could be adapted to reciprocal or one-way learnings by an SME embedded in a CIN. Then, for each learning, we classified these practices according to the building blocks of our conceptual model presented in Figure 1. Since these items were transposed to the context of an SME embedded in a CIN and not specifically proposed for the latter, we combined the results of this deductive literature analysis with those of an inductive approach. This method is convenient when the conceptual basis for a construct may not result in accurate items (Hinkin, 2005). The use of inductive approaches is even more appropriate for research in small businesses as it enables analysis of the important aspects of the SME environment and leads to gaining a holistic understanding of its inherent processes (Dana and Dana, 2005).

In this respect, we used the outcomes of our literature analysis to devise an interview guide. Then, we performed 20 semi-structured interviews with 12 SMEs and their partners within three CINs (mechanical, software, medical) in France and the UK. The interviewees were mainly the SMEs' managers and other individuals (engineers, researchers, etc.) who were closely involved in the networks. To cover a wide range of absorption practices, we selected SMEs from different sectors, which collaborated with a variety of actors (SMEs, research labs, etc.) possessing diverse expertise (Appendix B). The interviews were then transcribed and qualitatively analyzed using N'Vivo, therefore enriching the literature outcomes with 28 new practices. With regard to the variables describing the SME's context within the CIN, scales were developed for their related items based on the constructs' definitions in the extant literature. The constructs in this study are summarized in Table 2. Their associated items and their sources are provided in Appendix C.

Table 2 – Summary of the constructs used in this study

3.2. A quantitative phase to propose an ACAP operational measure for the SME according to its context within the CIN

Since ACAP is context-dependent (Lane et al., 2006), the purpose of this quantitative study is to develop a measure of this capacity for an SME embedded in a CIN, considering the peculiarities of this organization's context. For this reason, we employed the PLS-SEM (partial least squares structural equation modeling) approach in a novel way as explained hereafter.

3.2.1. Data collection

The items resulting from the qualitative phase were implemented in a survey questionnaire designed in collaboration with three other researchers. Participants were asked to respond by referring to a CIN experience and rating the items on a 1-6 likert scale ranging from strongly disagree to strongly agree. The questionnaire was then pre-tested with two new academic experts and two SME managers with prior experience in CINs. This approach enables upstream management of survey biases (Forza, 2002) and helps ensuring its face validity (Holden, 2010).

To determine the most appropriate way to conduct the questionnaire, we consulted several experts in innovation management in France, namely two consulting companies and four clusters in the textile, mechanical and digital sectors. These experts pointed out that the questionnaire was not suitable to feed large-scale surveys conducted by regional and national agencies. Indeed, they underlined that its purpose and format were not in line with those of such agencies. Therefore, they advised us to carry out our empirical study separately, using their contact databases. To form our sample, we employed a judgmental sampling method (Deming, 1990) instead of probability sampling, since we did not have access to the database of SMEs embedded in CINs, nor to statistics about their involvement in such networks by sector, size, etc. A pre-questionnaire was thus addressed to the SMEs' managers listed in the experts' contact databases in order to identify SMEs with previous CIN experience. From this preliminary questionnaire, we obtained 50 responses from SMEs' managers who stated that their firms were involved in collaborative innovation projects. The full questionnaire was then sent out to the constituted sample and was also distributed by the experts to their contact databases in order to obtain more responses. The SMEs' managers were asked to complete the questionnaire themselves if they were heavily involved in the CIN or else to forward it to the member of their organization who had a key role in the CIN. From December 2016 to May 2017, we collected 88 responses. However, for the variables used in this study, 14 of the received questionnaires were omitted as they represented a high rate of nonresponse. Table 3 presents the characteristics of the respondents from the 74 remaining observations, their respective SMEs and the CINs in which they were operating. These properties convey a high diversity of respondents.

Table 3 – Sample characteristics

3.2.2. Data analysis

This research aims to propose a contextualized operationalization of the ACAP for an SME embedded in a CIN. This operational measure guides the SME towards the most relevant ACAP dimensions and practices for its context, by establishing a priority order among them. To this end, we analyzed the

model in Figure 1 using the PLS-SEM approach, which was appropriate to the nature and purposes of this study as explained below:

PLS-SEM works efficiently to estimate complex models such as the one in Figure 1, comprising many constructs, several structural path relationships and many indicators per construct (Ringle et al., 2015). This characteristic is especially relevant when small sample sizes are used (Chin, 2010), as is the case in this research (74 responses). In addition, PLS-SEM can be particularly useful for SME research where there may be restrictions on sample sizes (Sarstedt et al., 2014). This approach meets further challenges faced by small business researchers who are confronted with an increasing complexity of theories and cause–effect models, over-surveyed respondents and decreasing response rates (Benavides-Velasco et al., 2013).

Additionally, PLS was used to analyze our structural model as it is appropriate for the purposes of this study. In fact, our research aims to elaborate a predictive process prioritizing the SME's ACAP dimensions and practices according to its context in a CIN. Therefore, it encompasses two objectives: it is necessary to first understand how the factors describing the SME's context impact its ACAP, to then be able to establish the predictive process. Regarding the first purpose, we used the PLS approach to build the first theoretical propositions on how the context of an SME embedded in a CIN impacts its ACAP. This purpose is consistent with the exploratory objectives of PLS-SEM, which does not intend to confirm a theory and test already established hypotheses as is the case for Covariance Based SEM (Peng and Lai, 2012). The PLS approach is also suited to other exploratory features of this study. For instance, the variables used are described according to theoretical definitions and empirical scales supplemented by exploratory interviews. In addition, there is little theoretical support to explain the links between the blocks of variables (Rigdon, 2012). PLS-SEM is even more relevant for such early stages of theory development in small business research (Thong et al., 1996).

Regarding the second purpose, the forecasting virtues of PLS (Tenenhaus et al., 2005) made it appropriate for establishing the predictive process, prioritizing the SME's ACAP dimensions and practices according to its context in the CIN. In preference to alternative forecasting approaches, such as logistic regression (Walker and Duncan, 1967) and neural networks (Bishop, 1995), we chose the PLS approach as it is suitable for prediction with latent variables such as the constructs in our model. This method provides the opportunity to predict explained variables by performing regressions from the scores obtained through a succession of factorial analyses (Tenenhaus et al., 2005). This property of PLS enables us to predict the scores of the nine dimensions composing the SME's ACAP according to the independent contextual variables impacting them. Therefore, it is possible to rank the ACAP dimensions and practices based on the predicted scores which would guide the SME towards the most critical absorption aspects for its context.

Hence, we used the PLS approach to analyze the structural model in Figure 1 whose constructs are modelled reflectively. Indeed, these latent variables are described by several items that were formulated using literature outcomes which were completed by our field study. Therefore, these items are non-exclusive manifestations of their associated latent variables (Petter et al., 2007) that might be enriched by future studies. When analyzing such a fully reflective structural model, Chin (2010) points out that the number of responses must be more than 10 times the greatest number of links between a dependent latent variable and independent ones. Since this number is four in our model, our sample size meets this constraint and enables the use of the PLS approach. However, because of the large number of structural links to be simultaneously estimated and the small size of our sample, we chose to analyze each ACAP dimension in an independent structural model to enhance the robustness of our results. Each of these nine models includes one ACAP dimension and the constructs characterizing the SME's context that impact this dimension. To analyze each model, we used the software SmartPLS 3.0 (Ringle et al., 2015). The analysis is done in two steps: validation of the measurement model and evaluation of the structural model (Hair et al., 2013). Table 4 summarises the procedures that were undertaken to evaluate our models.

Table 4 – Analysis approach adopted

4. Results

4.1 Proposition of a measurement scale from the qualitative study

Based on the insights of the qualitative study, we developed a measurement scale of ACAP for an SME embedded in a CIN (Appendix C). Accordingly, we confirmed the possible application to our unit of analysis of several practices proposed in the extant literature. We also enriched these outcomes with 28 new practices derived from the interviews, which have never been identified in prior research that developed ACAP measurement scales. These practices were reported either directly by the SMEs that performed them, or indirectly by their partners. Some interviewees cited practices that they did not in fact put into place but believed would have been useful. Of these new practices, 26 are related to reciprocal learning by the SME, while only two support its one-way learning. Most of the 26 practices identified for reciprocal learning refer to the issue of risk resulting from joint development of an innovation in a partnership setting. For instance, during the development stage, each SME needed to be aware of the risks and benefits related to collaborating with unusual partners such as competitors, researchers or large groups (Ass-Set4): "*For the laboratories, it is mainly an academic interest, while for the SMEs it's more about having something profitable at the end. It can create lags. As a result, some editors were not really open to the idea of working with a research lab"* (SME manager in the software CIN). During the operational stage, each SME had to deploy practices to prevent risks and

promote achievement of the network's goal. For example, some SMEs needed to rapidly raise any doubts in order to avoid misunderstanding that would inhibit the accomplishment of the common project objectives (App-Dev7): *"We had a lot of disagreements and that's fine. It is generally all too easy to muddle along with a product that nobody believes in simply because everybody respects one another, and they are afraid to express what they actually think. The more disagreements we had, the happier I was. At least we did not reach a point where something was not working and someone said well, I knew that would not work"* (SME manager in the medical CIN).

The interviews also stressed the importance of differentiating between the two CIN stages to operationalize ACAP for reciprocal learning. Our results suggest that while some ACAP practices may appear similar across these phases, they target different goals. The organization of exchanges with other project actors to support the SME's assimilation within each stage could illustrate this point. In the setting-up phase, these face-to-face interactions aim to converge towards a common vision of the innovation (Ass-Set2): "*We organized common review sessions to settle on the machine requirements which we compiled in preliminary drafts and descriptive documents. Once we had discussed these issues, we started working on our contributions*" (SME manager in the mechanical CIN). In the operational stage, these exchanges are more thematically oriented and involve only the organizations that are jointly working on specific innovation development and commercialization issues (Ass-Dev2): "*There were different types of meetings: R&D meetings bringing together some of the editors, project steering meetings, and finally commercially oriented and marketing meetings"* (SME manager in the software CIN).

Finally, the interviews corroborated that an SME deploys ACAP for one-way learning simultaneously as it pursues a reciprocal learning to contribute to the common innovation goal (Acq-One6): "*So in the objectives that were a bit secondary and directly relevant to us, we made sure that our technical team would become more competent regarding the technologies that are used in the project in order to take advantage of them for our own products*" (SME manager in the software CIN).

4.2. Preliminary quantitative analysis of the dataset

Before evaluating the validity and reliability of our models we performed, using XLSTAT (Addinsoft, 2016), several initial data processing operations in order to refine the underlying factor structure. First, we managed the missing values within the 74 observations by applying the NIPALS algorithm (nonlinear estimation by iterative partial least squares) which is particularly suitable for the PLS approach (Tenenhaus, 1999). The algorithm relies on imputing the observation containing the missing value with the most probable values of the other observations. Then, we carried out Harman's single factor test to check for possible method bias resulting from the data collection approach (Podsakoff et

al., 2003). This test resulted in a 37.065% variance explained by the single factor therefore suggesting the absence of method bias.

Finally, before assessing the measurement and structural models, it is necessary to examine the constructs' unidimensionality (Urbach and Ahlemann, 2010). Unidimensionality is defined as the existence of one latent trait underlying the data (Hattie, 1985). In this respect, we assessed unidimensionality of the constructs included in our nine models by applying the tests described in Table 4. As shown in the results (Appendix D), the indicator Cent-Role4 reflecting involvement in intellectual property (IP) loaded more on the construct Int-Act (representing the SME's motivations to absorb knowledge within the network) than on Cent-Role and was therefore attached to the former. Also, the construct Rel-Prior was separated into two latent variables, Cog-Dist and Coopetition, whose items respectively express the cognitive distance between the SME and the other actors (Nooteboom et al., 2007) and the presence of coopetition between them (Fernandez et al., 2014). Indeed, the less companies share similar organizational cultures and knowledge interpretation bases, the more important is the cognitive distance between them (Nooteboom et al., 2007). Also, the more similar companies are in terms of expertise, activities and commercial orientations, the higher the risks of moving from a collaborative to a competitive relationship (Lubatkin et al., 2001). Although this separation of Rel-Prior into two new constructs increased to five the greatest number of links between a dependent latent variable and independent latent variables, the size of our sample still allowed us to implement the PLS method. After these preliminary analyses, we performed the remaining steps of PLS-SEM to assess each of our nine models independently.

4.3. Assessment of the measurement models

Within each model, we assessed the reliability of the items associated with the constructs according to the tests described in Table 4. The retained items' loadings are introduced in the diagonal values of the matrices in Appendix E. Then the results of construct reliability and convergent validity are displayed in Table 5. Finally, discriminant validity was assessed through examination of cross-loadings (Appendix E), and by verifying the Fornell–Larcker and the HTMT criteria (Table 6).

Table 5 – Constructs' reliability and convergent validity

Table 6 – Fornell-Larcker and HTMT criteria

4.4. Assessment of the structural models

Table 7 gathers the results of the structural models' assessment. We first evaluated the models' predictive accuracy, which displayed R^2 values between 0.477 and 0.714. These results exceeded the threshold of substantial R^2 (0.26), suggesting good predictive accuracy. Also, all the models were statistically significant, with F ranging from 12.410 to 37.114 and $p<0.001$. Then the quality of each model was assessed using relative GoF (goodness of fit) indices which ranged between 0.734 and 0.863, sufficiently close to 1 to suggest good model fit. Finally, the Q^2 values of the models varied from 0.219 to 0.369 and were all above zero, confirming that the models exhibit predictive relevance.

With regard to assessment of the structural paths, results show that the construct Cent-Role has a positive and significant impact on the three ACAP dimensions of the SME's contribution to the setting-up phase, as does the construct Ext-Act. This latter variable also positively impacts the application dimension of the SME's one-way learning. As for the Int-Act construct reflecting its motivations to take part to the CIN, it positively influences the SME's application dimension for its contribution to the development phase and for its one-way learning, as well as the acquisition dimension for this learning. Results also show that the construct Cog-Dist has a positive and significant impact on assimilation dimensions for the SMEs' one-way learning and for its contribution to the development phase, but also on the acquisition dimension within this phase. Finally, the construct Coopetition has a significant effect on the nine ACAP dimensions, which are all positive except for the acquisition dimension within the SME's one-way learning. We further interpret these results in the discussion part.

Table 7 – Structural model results

4.5. Predicting the relevant ACAP dimensions and practices according to the SME's context within the CIN

Analysis of the measurement models (4.3) enabled us to propose a refined measure for the ACAP of an SME embedded in a CIN. Nevertheless, since the context of such an SME induces variance in its ACAP, it is more relevant to propose an operationalization of the ACAP that is adjustable according to the SME's context within the CIN. To take this context into consideration, we first needed to understand how it impacts the SME's ACAP. In this regard, analysis of the structural models (4.4) enabled us to identify the factors describing this context, which have a significant impact regarding each dimension of the SME's ACAP. Based on these results, we tapped into the prediction virtues of the PLS approach to propose a contextualized measure of the ACAP for an SME embedded in a CIN. In this regard, after eliminating the non-significant paths depicted in Table 7, we ran the PLS algorithm again on each of our nine models to calculate the normalized weights of the remaining contextual constructs' items (Table 8) and the coefficients of the kept paths (Table 9).

Table 8 – Items' weights resulting from PLS algorithm

Table 9 – Coefficients used in the prediction equations

Based on these elements, we formulated the equations predicting each ACAP dimension's score according to the SME's context. These scores are predicted following several steps that we explain below by applying them to predict the score of the dimension Acq-Set as an example (Figure 2):

- The SME first informs its context by rating each of the items describing the contextual factors (Cog-Dist, Coopetition, Cent-Role, Ext-Act, Int-Act) on a scale of 1 (strongly disagree) to 6 (strongly agree). In our example, the SME would rate the items associated with the contextual factors impacting the dimension Acq-Set which are depicted in Figure 2.
- The contextual factors' scores are then calculated as an aggregation of their items (informed by the SME in the previous step) pondered by their normalized weights which resulted from the PLS algorithm (Table 8). In our example, the contextual factors' scores are calculated as follows:

$$Ext - Act = \begin{pmatrix} 0.107 & 0.891 & 0.001 \end{pmatrix} \begin{pmatrix} Ext - Act1 \\ Ext - Act2 \\ Ext - Act3 \end{pmatrix}$$

$$Cent - Role = \begin{pmatrix} 0.282 & 0.423 & 0.295 \end{pmatrix} \begin{pmatrix} Cent - Role1 \\ Cent - Role2 \\ Cent - Role3 \end{pmatrix}$$

$$Coopetition = \begin{pmatrix} 0.276 & 0.724 \end{pmatrix} \begin{pmatrix} Rel - Prior3 \\ Rel - Prior4 \end{pmatrix}$$

- The score of each ACAP dimension is calculated as the sum of a residual constant and the aggregation of the contextual latent variables' scores resulting from the previous step, weighted with their associated path coefficients. The constant and the path coefficients result from the PLS algorithm and are provided in Table 9. These predicted dimensions' scores naturally range between 1 and 6 (as do the items associated with the contextual factors which were informed by the SME in the first step). In our example, the score of Acq-Set is predicted according to the equation:

$$Acq - Set = 0.457 + 0.164 \times Ext - Act + 0.406 \times Cent - Role + 0.304 \times Coopetition$$

Figure 2: Illustration of the calculation model to predict the score of the dimension Acq-Set

Hence, the formulated equations predict the scores of the nine ACAP dimensions according to the SME's context, which can be ranked to identify the most critical ones for the SME. Based on the

dimensions' predicted scores, the initial weights of their associated items (Table 8) resulting from the PLS algorithm are revised by applying the following equation for each item i associated with an ACAP dimension j:

$$New\ weight_{item\ i} = \frac{Initial\ weight_{item\ i}}{6} \times Predicted\ score_{ACAP\ dimension\ j}$$

The comparison of these new weights across the items (i.e., ACAP practices) associated with the nine ACAP dimensions allows for ranking the practices and hence identifying the most critical ones for an SME to implement primarily according to its context within a CIN. Let us take the example of an SME's context for which the calculation of the predicted scores of the three ACAP dimensions within the setting-up stage results in 3 for Acq-Set, 2 for Ass-Set and 6 for App-Set. The weights of these dimensions' practices before and after the prediction of the dimensions' scores are introduced in Figure 3. The priority order of the practices associated with these three dimensions changed after the introduction of their scores, predicted according to the SME's context. Indeed, before the contextualization, the three most critical practices were (Acq-Set11, Ass-Set3, Acq-Set7), while they became (App-Set2, Acq-Set11, App-Set8) after considering the SME's context within the CIN.

Figure 3 – Example of changes within the practices' ranking for the ACAP dimensions of the CIN setting-up stage due to the introduction of the SME's context

In sum, this approach makes it possible to propose a contextualized operational measure of the ACAP for an SME embedded in a CIN. On the one hand, the prediction of the dimensions' scores identifies the most critical ones for the SME and raises its awareness regarding those it should master as a priority. On the other hand, the introduction of the dimensions' scores makes it possible to revise the weights of their associated practices which are compared across the nine dimensions to identify the most important ones for the SME's context. Thus, an order of priority is established both at the levels of the ACAP dimensions and the practices making the ACAP operational measure adjustable to the SME's context within the CIN.

5. Discussion

This study enabled understanding of the impact of an SME's context within a CIN on its absorptive capacity (ACAP). This context is described according to five factors, namely external activators, internal activators, relative prior conditions that are split into coopetition and cognitive distance, and finally central roles. These factors were found to have distinctive effects on the SME's learning

perspectives. On the one hand, for reciprocal learning, the factors' influence mainly differs according to the two stages of the CIN. On the other hand, for one-way learning, the differentiated effects of these factors are perceived at the level of the three ACAP dimensions. Furthermore, this research showed that the absorption manner of an SME embedded in a CIN necessarily changes depending on the variance induced by its context. These changes are modelled according to a predictive process which guides the SME toward the most critical absorption dimensions and practices for its context. We discuss these findings below.

5.1. The influence of the factors describing the SME's context differs according to the two stages of its reciprocal learning

Our results underline that **external activators**, reflecting highly dynamic and competitive environments (Zahra and George, 2002), induce a high knowledge acquisition, assimilation and application during the first phase of the SME's reciprocal learning. Indeed, to better exploit its capabilities for its contribution to the network innovation objective, the SME needs to be aware of the current technological and market trends in its dynamic environment (Nadkarni and Chen, 2014). Also, an assimilation of the risks and benefits of joining a CIN is needed to assess the collaboration relevance for responding to the SME's environmental dynamism (Osland and Yaprak, 1995). The presence of external activators would even compel the SME to make substantial efforts in organizing its contribution to the network to ensure that the defined performance objectives and business model are aligned with the level of its environment dynamism (Heij et al., 2014). As for the SME's ACAP during the second phase of its reciprocal learning, none of the dimensions is significantly impacted by external activators. While the setting-up phase defines the SME's collaboration strategy to participate in the CIN, the development phase represents the way it operates to accomplish its defined objectives. The strategic nature of the first phase and the operational nature of the second one (Camarinha-Matos et al., 2009) could explain why external activators only impact the SME's ACAP during the network setting up, since environment turbulence primarily induces changes at the strategic level (Johnson et al., 2003).

Concerning the **central roles** factor, we found that the more the SME has a central position within a CIN, the more it will deploy an intensive ACAP during the network setting-up phase. During this stage, boundary actors play a critical role in investigating the innovation environment in order to identify inspirational ideas (Jeppesen and Laursen, 2009) and actors possessing critical competencies for the project (Goduscheit, 2014). They are also heavily involved in organizing regular exchanges with all the actors in the CIN (Hauschildt and Schewe, 2000) to set it up and formalize the innovative idea. In addition, they have to define the project planning and set up the collaborative techniques (Gemünden

et al., 2007) to manage the interfaces between the network actors. As for the SME's contribution to the innovation development phase, our results suggest that its centrality has no significant effect on its ACAP. An explanation of this result could be that, during the operational stage, each actor acquires knowledge for its own responsibilities and interacts mainly with the partners at the interface of its contribution. Exchanges gathering the whole network which would require high coordination are rarely needed, as was underlined by an SME manager in the qualitative phase of this study: "*We have regular partner meetings and also mandatory meetings with the organization that funds us. Everyone gives presentations on how we are progressing. We do not drag people into big meetings where everyone is present just for the sake of it*" (SME manager in the medical CIN).

We found that there is no significant effect of the SME's **internal activators** on its ACAP for both stages of its reciprocal learning except for the application dimension in the CIN operational phase. The non-significance result for the three ACAP dimensions within the setting-up phase could be explained by the fact that, at the early stages of the project, the SME's own objectives are still not clearly formalized, as they can be redefined to meet the common network goals or to reap potential benefits of which the SME was not aware before its interactions with the identified partners. As for the SME's acquisition and assimilation for its contribution to the CIN operational stage, the non-significance result of internal activators regarding these dimensions can be accounted for by the fact that they do not directly induce benefits, but rather represent intermediate stages to meet the SME's objectives. This is not the case for the application dimension in the CIN operational phase, which requires from the SME substantial efforts to react on its internal activators by finalizing its contribution to the project, efficiently exploiting knowledge to meet its IP objectives or, more generally, achieving highly demanding financial and strategic goals (Ahuja, 2000).

Cognitive distance was found not to have a significant effect on the SME's ACAP during the setting-up phase. This could be explained by the fact that, at this stage, the SME does not need to understand and integrate advanced technical knowledge from the other network actors. Their interactions focus on organizing the CIN, with knowledge related to project management, which may need less cognitive alignment. Another explanation may be related to a bias resulting from the respondents' representation of the knowledge type that they considered when they replied. This suggestion is supported by the results of our qualitative phase. Indeed, most of the practices resulting from the interviews (Appendix C) show that respondents naturally think primarily about technological knowledge, probably because most participants in CINs have a technical background. During the operational stage, we found that the cognitive distance has a positive and significant impact on acquisition and assimilation dimensions while this factor does not influence knowledge application. The more the knowledge bases and fundamental values (Nooteboom et al., 2007) are different between the SME and its partners, the more it needs to be informed about and to assimilate their constraints and requirements

in order to foster its contribution to the common innovation goal. Then the SME and its partners apply the knowledge according to what they have commonly defined in the previous dimensions. Most of the time, the innovation in the CIN is split into several sub-products. Each of them can be finalized by one partner in the CIN corresponding to an efficient division of tasks (Islam et al., 2018). Therefore, this autonomous application of knowledge does not require a cognitive proximity between the partners.

Concerning the **coopetition** factor, this study's findings provide evidence that collaborating with potential competitors who possess similar competencies and commercial orientations is the major factor that influences all the ACAP dimensions of an SME embedded in a CIN, both for the setting-up and development phases. As innovation requires combining different types of knowledge (Taylor and Greve, 2006), firms operating in an environment with poor knowledge diversity are compelled to strengthen the width and breadth of knowledge acquisition to accomplish innovating outcomes (Laursen and Salter, 2006). Coopetition was also found to have a positive significant effect on the SME's assimilation dimensions for both stages of its reciprocal learning. In fact, the SME needs to assess the risks and benefits of coopetition (Galkina and Lundgren-Henriksson, 2017; Ritala, 2012), before deciding to join a network with potential competitors. During its contribution to the innovation development, the SME intensifies its assimilation efforts to appreciate the propositions of its competitors which may be better than its own ways of using knowledge, and therefore overcome the narrow-mindedness that can occur in a coopetitive situation (Le Roy and Fernandez, 2015). Besides, coopetition would encourage the SME to provide more efforts in knowledge application during the upstream phases of the project, by contracting its risky relationships with other actors (Bouncken et al., 2015) and by establishing a business model that respects everybody's interests. These efforts are also needed for efficient knowledge application during the CIN operational stage to prevent the SME from having its market invaded by competitors (Lubatkin et al., 2001).

5.2. The influence of the factors describing the SME's context differs according to the three dimensions of its one-way learning

External activators were found to have a determinant effect only on the SME's application dimension while they had no impact regarding the SME's acquisition and assimilation for its one-way learning. Indeed, firms operating in highly dynamic environments are required to explore all the possibilities of applying learnt knowledge likely to improve their performance (Jantunen, 2005), by initiating innovation projects (Christensen et al., 1998) and restructuring their organizational capabilities to favour strategies enabling them to sustain a long-term performance (Zahra and George, 2002). Therefore, they won't focus on initiatives mostly intending to increase their stock of knowledge, as these strategies are only beneficial in the short term (Denicolai et al., 2016).

Our results suggest that high levels of **internal activators** mostly compel an SME to deploy its ACAP in order to acquire and apply external knowledge for its one-way learning. In fact, the SME's willingness to strengthen its technical capital and address strategic challenges incites it to be particularly attentive to acquiring potentially valuable knowledge for its organization (Ahuja, 2000). Such efforts are also needed to quickly apply the acquired learnings and capitalize on its contribution to the project. In fact, the more the SME's long-term performance objectives are challenging, the more it will implement systematic transformation routines and change conduct practices (Zahra and George, 2002) to foster the application of newly acquired knowledge.

As for **cognitive distance**, our findings show that this factor only induces high levels of assimilation. Indeed, new knowledge acquired by the SME through the CIN can embody heuristics that differ considerably from those used by the organization (Leonard-Barton, 1995). Thus, intensive interpretation and exchanges within the SME are needed in order to understand the potential of this new knowledge for its own organization and align it with its frame of reference (Mendi et al., 2020; Zahra and George, 2002).

Finally, **coopetition** has a negative significant effect on the SME's acquisition dimension and positively impacts the two other dimensions for its one-way learning. In fact, the more similar the SME's expertise with regard to the other network actors, the less this organization is motivated to struggle for knowledge acquisition, as this situation does not bring new complex or attractive knowledge requiring special effort. The absence of such valuable knowledge is also due to the fact that companies that are in a coopetition situation are not enticed to share their knowledge and may deploy strategies of asymmetric or hidden information when they consider the knowledge they possess to be highly valuable (Lubatkin et al., 2001). The positive effect of coopetition on the SME's assimilation and application stems from its need to quickly find and pursue valuable usages of learnings acquired through the project, in order to anticipate or react to competition (Powell, 1998), especially when the partners have a substantial capacity to appropriate new knowledge and access to markets.

5.3. The primary absorption dimensions and practices change according to the context of an SME embedded in a CIN

This study established a model that predicts a priority order of the ACAP dimensions and of the practices across these dimensions, considering the peculiarities of the SME's context within the CIN. The SME should be aware of this ranking in order to properly absorb knowledge within the CIN and achieve successful reciprocal and one-way learnings (Das and Teng, 2000; Lubatkin et al., 2001). This research thereby converges towards the studies that emphasize the dynamic nature of ACAP (Zahra

and George, 2002) and learning (Eisenhardt and Martin, 2000; Zollo and Winter, 2002), which must be properly managed according to organizational environments in order to achieve sustained benefits.

In the same vein, this study provides elements of response to the gap identified by Flatten et al. (2011), who emphasized the need to explore how the relative importance of each ACAP dimension would differ according to an organization's contextual setting. In this respect, to efficiently achieve reciprocal and one-way learnings, the SME will absorb knowledge differently depending on the characteristics of its partners, its role within the network as well as its internal and external environments.

6. Conclusion

6.1. Theoretical implications

Although CINs constitute a key organisational mode for SMEs' innovation and competitiveness (Lee et al., 2010; Tsai, 2009), no research had explored how these organizations can implement ACAP in such a setting. Thus, this study covers this gap by proposing an operationalization of the ACAP adapted to the context of an SME embedded in a CIN. As such, it presents several theoretical contributions. First, this research contributes to the field of work developing operational measures of ACAP. This study follows a mixed method to propose a contextualized operationalization of the ACAP for an SME embedded in a CIN. Existing research hardly used such a method to investigate ACAP (Bröring and Leker, 2007; Flatten et al., 2011; Murovec and Prodan, 2009; Saad et al., 2017; Sedoglavich et al., 2014). In addition, among these studies, only that of Flatten et al. (2011) proposed a multidimensional operationalization of this construct. Our research stands out by the development of an operational assessment of this capacity in a CIN context which, additionally, is contextualized according to the factors impacting the ACAP.

Second, this research underlines that SMEs pursuing an open innovation strategy develop ACAP to fulfil reciprocal and one-way learnings. Thus, it provides some insights to complete the lack of knowledge about ACAP in the context of SMEs as highlighted by Hossain et al. (2016). Through their participation in a CIN, SMEs develop their capacity to absorb external knowledge in order to co-develop and commercialize an innovation with the other CIN actors (Ferreras-Méndez et al., 2016). This open innovation strategy also helps them to develop their own ACAP by transforming external knowledge into internal innovation development and commercialization so as to improve their technological and financial performances (Rothaermel and Hess, 2007). For both reciprocal and one-way learnings, our study shows that a coopetitive environment will increase the companies' efforts to deploy their ACAP, regardless of their level and type of expertise.

The last contribution is of a methodological nature. We used the PLS method by drawing upon its forecasting features (Joreskog and Wold, 1982) to establish a predictive process that explains the activation of ACAP dimensions and practices for an SME embedded in a CIN according to the contextual determinants of ACAP. While researchers often emphasize that predictive capabilities are a strength of the PLS approach, methodological advances and applications in this direction are rare (Carrion et al, 2016). To our knowledge, none of the studies in the management field focusing on forecasting used this approach. Accordingly, this research provides a methodological example for establishing a forecasting model based on PLS.

6.2. Managerial implications

Several managerial implications can be derived for this research. Firstly, by proposing an ACAP measure adapted to the context of their participation in CINs, SMEs can be guided towards the most critical absorption dimensions and practices they need to master. Accordingly, these practitioners would be able to determine where additional investments should be made to upgrade and improve the use of ACAP. In this regard, this contextualized ACAP measure can be used upstream of an SME's contribution to a CIN, to anticipate its capability gap and implement the necessary improvement actions that would foster its reciprocal and one-way learnings. The SME can also mobilize this instrument to evaluate its ACAP during its participation in a CIN in order to take a step back from its current practices and set up the relevant corrective actions.

Secondly, this contextualized ACAP measure could be useful to manage an SMEs' network efficiently. Indeed, carrying out an ACAP evaluation by each participating SME would allow the network to better configure itself in order to accomplish the common innovation goal. In this regard, the tasks and responsibilities are distributed according to the capabilities of each actor, e.g., SMEs that are best suited to boundary-spanning roles. This early assessment by the initial network also allows the identification of new actors to fill the CIN's deficit regarding certain practices. For example, if none of the present actors has expertise in CIN coordination, they can call on an open innovation intermediary (Kokshagina et al., 2017) able to stimulate the collaboration and solve technical issues in a networked configuration. Furthermore, such assessment can be performed during the development phase to identify the risks of the current network structure and review it if necessary. This network-level evaluation is of particular interest for SMEs that are used to innovating together, as it would generate learnings to better prepare and carry out their future common projects.

Thirdly, our results provide important insights into channels whereby government policies might foster innovation. Indeed, we showed that SMEs can benefit from their CIN experience to overcome the difficulties they usually face in investing and developing ACAP alone (Rojas et al., 2018; Saad et al.,

2017; Tojeiro-Rivero and Moreno, 2019). This suggests that policy makers should propose instruments stimulating the participation of SMEs in CINs, which would enhance their ACAP and enable them to develop future innovations either on their own or in an open innovation setting (Leckel et al., 2020; West et al., 2014). These investments in policy instruments would even bring further benefits for the innovation landscape. In fact, the innovation outcome from a CIN may be naturally superior due to the multidisciplinary knowledge of the CIN actors (Lee et al., 2010). Therefore, policy makers should establish regimes supporting the quality of this collaborative innovation but also of the processes it involves (Veak, 2006). In addition, innovation relies on technologies acting in relation with a host of social and cultural factors (Smith and Stirling, 2017). Indeed, the use of technologies by given groups and for particular purposes is assumed by those involved in their development (Akrich, 1992). This suggests that the established regimes should leverage this socio-technical property of innovation to foster its diffusion (Berkhout et al., 2004). Accordingly, policy makers might propose a framework that supports innovation democracy by connecting and involving actors who are capable of challenging the direction of innovation (Smith and Stirling, 2017). These actors include organizations with diverse technological, social and cultural backgrounds, but also socially embedded end users likely to adopt the developed innovation, as they would stimulate market readiness (Berkhout et al., 2004).

7. Limitations and future research avenues

This empirical study is not without limitations. First, the sample only gathers industrial SMEs. Supplementary research would be required to assess the degree to which the proposed operational ACAP measure holds in large groups. Indeed, compared to SMEs, bigger companies focus mainly on R&D in open innovation efforts (Lee et al., 2010), possess more technological assets and a greater ability to access external resources (Narula, 2004).

Secondly, it would be relevant to extend the ACAP measure developed in this study by performing further analyses in order to conceive a measurement scale for this construct that is validated according to Churchill's paradigm (Churchill, 1979). Indeed, the nonexistence of such an ACAP measurement scale for an SME embedded in a CIN compelled us to proceed to a qualitative phase in order to propose items describing this construct, and then to a quantitative approach in order to refine them. Although the measure developed enabled the fulfilment of the prediction purposes of this study, further research might complement the two steps we achieved by conducting a confirmatory analysis using data collected from a new sample of respondents in order to generate a measurement scale following the recommendation of Churchill (1979). This last step would provide the means to firmly decide on the significance of some items and structural paths that were eliminated in this study.

Third, further quantitative studies could help overcome some of the limitations of our judgemental sample. Due to the impossibility of relying on a probabilistic sample, we used a judgemental approach to identify respondents and were careful to manage its biases throughout data collection and analyses. Although the final sample contains a high diversity of respondents, it is not guaranteed to be representative of the population studied. Therefore, caution should be exercised when generalizing from our findings to specific SME contexts. Future research might explore the significance of our model under various SME characteristics.

Fourth, since our unit of analysis was an SME embedded in a CIN, the respondents were asked to complete the survey by assessing their ties with regard to the network as a whole. Hence, we did not manage to appreciate the differentiated effects of dyadic relationships within the same CIN. We therefore encourage future research on this topic to explore how an SME can develop different relative ACAPs (Land and Lubatkin, 1998) depending on the nature of each of its bilateral relationships. This would also complete the work of Mei et al. (2019) who investigated SMEs' ACAP in business ecosystems and showed that an SME develops different ACAPs with two types of partners, namely prominent organizations and service intermediaries.

Finally, to facilitate the appropriation of this study's results by practitioners, a maturity tool integrating the identified practices and the developed prediction process could be designed. Maturity tools are assessment supports which raise an organization's awareness regarding its strengths and weaknesses in order to initiate the necessary improvement actions (Maier et al., 2012). Such a tool would therefore be adequate to guide the SME towards the critical absorption aspects for its context. Future research would define the structure of this tool and the maturity criteria against which the SME should be judged. In addition, an action research process could be adopted to align the tool with the SMEs' reference frame, assess its usefulness and demonstrate the transferability of the inferences resulting from the mixed method used in this study (Venkatesh et al., 2013).

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SMEs embedded in Collaborative Innovation Networks: How to measure their absorptive capacity ?

Highlights:

– An SME deploys its ACAP dynamically and differently to align with a CIN's context

– This context affects the SME's reciprocal learning differently across the CIN stages

– Coopetition is a determinant of all ACAP dimensions for an SME embedded in a CIN

– SMEs with central roles in a CIN deploy an intense ACAP in the CIN's early stages

– Cognitive distance triggers assimilation inside the SME and during CIN's development

SMEs embedded in collaborative innovation networks: How to measure their absorptive capacity ?

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SMEs embedded in collaborative innovation networks: How to measure their absorptive capacity ?

Abstract

SMEs increasingly participate in collaborative innovation networks (CINs), enabling them to access valuable external knowledge from other actors while maintaining high levels of internal competencies. The SME absorbs this knowledge to achieve reciprocal learning through its contribution to the common CIN goals, and one-way learning to improve its own organization's performance. This knowledge absorption varies according to the SME's context, described with factors such as the turbulence of its external environment, the motivations to contribute to the CIN, or the cognitive distance separating it from the network actors. To better guide this knowledge absorption, this research uses a two-stage mixed method to propose a contextualized operational measure of absorptive capacity (ACAP) for an SME embedded in a CIN. A qualitative phase consisting of semi-structured interviews was implemented first and enabled characterizing the SME's ACAP through a set of practices and dimensions that it could implement. Then a quantitative phase using the partial least squares (PLS) method established a model predicting the absorption dimensions and practices that the SME should master primarily according to its context in the CIN. Hence, this study provides SMEs with an instrument to assess their strengths and weaknesses with regard to ACAP in CINs.

Keywords

SME, Collaborative network, Open innovation, Absorptive capacity, Inter-organizational learning, Partial least squares

1. Introduction

SMEs possess significant potential for innovation thanks to their organizational agility and their proximity to the market (Sáez-Martínez et al., 2014). Nevertheless, innovation also requires the combining of diversified and highly specific knowledge that is rarely available within SMEs (Bougrain and Haudeville, 2002). In fact, these organizations tend to specialize in order to maintain a competitive market position (Narula, 2004). Consequently, they adopt open innovation alternatives to access complementary knowledge and improve their innovation capabilities (Spithoven et al., 2013). More particularly, SMEs join collaborative innovation networks (CINs) (Van de Vrande et al., 2009) involving heterogeneous actors, who work together in a climate of trust and intensive exchange in

order to achieve a mutually beneficial innovation goal within a limited period of time (Graça and Camarinha-Matos, 2017). Indeed, a recent report by the European commission (European commission, 2017) shows that 49% of SMEs innovate through collaboration with other partners, which explains European policy efforts to propose incentives promoting collaborative innovation by SMEs. These ad-hoc networks enable SMEs to pool their resources with other actors, share the risks and benefits inherent in the innovation development (Lee et al., 2010), and access external complementary knowledge for innovation provided by these actors (Van de Vrande et al. 2009).

To make efficient use of such externally accessible knowledge for innovation purposes, companies need to deploy their absorptive capacity (ACAP) (Zahra and George, 2002), which is very sensitive to the context of each organization (Lane and Lubatkin, 1998). ACAP is a multidimensional learning capability that reflects the organization's ability to acquire, assimilate and apply new knowledge to commercial ends (Cohen and Levinthal, 1990). Firms need to be aware of knowledge absorption modes in order to foster the success of their innovation strategies (Saad et al., 2017). Accordingly, several authors have proposed operationalizations of this concept to guide knowledge absorption by organizations that are engaged in innovation developments in intra-organizational (Flatten et al., 2011; Jansen et al., 2005; Ter Wal et al., 2011) but also inter-organizational contexts of innovation (Jimenez-Barrionuevo et al., 2011; Lane et al., 2001; Thuc Anh et al., 2006).

However, no prior research provides an ACAP operationalization that is adapted to the context of an SME embedded in a CIN. This gap cannot be covered by the transposition of the existing operational measures to an SME in a CIN for several reasons. First, intra-organizational operationalizations cannot be mobilized because an organization's ACAP in an alliance context is subject to the characteristics of its partners, such as their organizational structures and their commercial orientations (Lane and Lubatkin, 1998). Second, most of the existing inter-organizational operationalizations are proposed for long-term alliances, making them inadequate for actors embedded in ad-hoc collaboration networks. In fact, these actors absorb knowledge primarily to contribute to the achievement of an innovation goal within a limited period of time (Najafi Tavani et al., 2018); while in long-term alliances, the partners' ACAPs support the continuous development of capabilities that each of them uses to sustain his competitive position (Lubatkin et al., 2001). Therefore, the challenges of firms embedded in CINs regarding knowledge absorption and the creation of new capabilities and future business opportunities are markedly different from those faced by the actors pursuing operational efficiency in stable longer-term alliances (Valkokari and Helander, 2007). Finally, the few ACAP operational measures used in studies of collaborative inter-organizational contexts focus on large firms (Nieto and Santamaria, 2007; Jayaram and Pathak, 2013), and are therefore not suitable to SMEs embedded in CINs. Indeed, due to their limited systems and financial resources for gathering vital information on potential collaborators, SMEs tend to use professional intelligence processes for scanning and monitoring their technological

environments in a less intensive, structured and systematic way than big companies (Lee et al., 2010). Also, they usually do not collaborate with other partners under IP and power conditions that are similar to large firms (Spithoven et al., 2013).

Hence, knowing that ACAP depends on the organization's context and should be operationalized accordingly (Lane et al., 2006), this research aims to propose an operationalization of the ACAP adapted to the context of an SME embedded in a CIN. Previous studies underlined a variety of factors characterizing this context which are likely to induce variance regarding this SME's ACAP. For instance, this capacity is subject to the influence of "external activators" related to the turbulence of the external environment, "internal activators" reflecting the internal conditions that would compel an organization to absorb external knowledge (Zahra and George, 2002), "relative prior conditions" that describe the firm's similarities and differences regarding the other network actors in terms of organizational structures and commercial orientations (Lubatkin et al., 2001) and finally, "central roles" which correspond to the level of the organization's centrality within the network (Tsai, 2001). Therefore, a challenge is to propose an operationalization of the ACAP for an SME embedded in a CIN which takes into consideration the different factors describing its context. As such, the following question is raised: *How can we provide an SME with an operational measure of its ACAP considering its context within a CIN?*

To address this question, we adopted a mixed-method approach (Venkatesh et al., 2013), comprising a qualitative phase followed by a quantitative phase. The first, consisting of a thorough literature review and semi-structured interviews with SMEs and their partners within CINs, provided a better understanding of both ACAP practices for such an SME and the factors describing its context. The second, quantitative phase, aimed to generalize the qualitative results and formulate prediction equations that establish an order of priority for the absorption dimensions and practices according to the SME's context. Hence, the ACAP operationalization resulting from this mixed methodology requires the characterization of the SME's context based on the factors impacting ACAP. Accordingly, the prediction equations determine the most critical absorption dimensions and practices for the SME to master and in regard to which it would measure its ACAP. This article is organized as follows: first, section 2 is devoted to the development of our theoretical framework; then, section 3 explains the different steps of our mixed methodological approach; our results are introduced in section 4; finally, this article concludes with a discussion of its main contributions, limitations and avenues for future work.

2. Theoretical background

2.1. CINs for SMEs' open innovation

To keep a stable position in the market, SMEs try to maintain a sufficiently high level of internal competencies in only a few or even a single technological area (Narula, 2004). Consequently, to improve their innovativeness, SMEs rely on open innovation alternatives (Lee et al., 2010) enabling them to reap the benefits of their external environment and update their learning (Saad et al., 2017). While SMEs may adopt different open innovation strategies (Van de Vrande et al., 2009), a large number of studies indicate that collaborating with other organizations for innovation is a key alternative for SMEs (Edwards et al., 2005) even more than for large firms (Leckel et al., 2020; Wright and Dana, 2003). In this respect, SMEs join collaborative innovation networks (CINs) made up of "*a variety of entities (e.g. organizations and people) that are largely autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, social capital and goals, but that collaborate to better achieve common or compatible goals, thus jointly generating value*" (Camarinha-Matos et al., 2009:49). These networks represent symbiotic collaboration between two or more firms to improve the value of the output by reducing cost and time to market and enhancing the customer service to the benefit of all involved parties (Etemad et al., 2001). The actors learn together through mutual sharing of knowledge, and exploit jointly created innovation that makes them interdependent (Etemad et al., 2001; Lubatkin et al., 2001).

CINs have increasingly attracted both researchers' and practitioners' attention as an appropriate solution to overcome the difficulty for an individual company of developing innovations with sustained benefits (Najafi Tavani et al., 2018). In this regard, several scholars have examined the role of different network characteristics (power, size, centrality, structural holes and network density) in the development of firms' learning and innovation through CINs (La Rocca et al., 2016). Other researchers have investigated how collaborating with different external actors such as suppliers, customers, competitors, and research organizations results in expansion of a firm's existing knowledge base and advances its innovation capability (Clauss and Kesting, 2017; Kafouros et al., 2020). For SMEs, prior studies underline that these firms can develop various forms of collaborative innovation arrangements (Leckel et al., 2020). Much of the academic literature has investigated innovation networks solely involving SMEs (Corso et al., 2003). These collaborative configurations enable the SMEs to pool their resources and share the innovation risks and benefits (Lee et al., 2010) while maintaining their independence and implementing their own decision- making processes as part of the network (Valkokari and Helander, 2007). SMEs can also collaborate with large firms in dyadic buyer-supplier relationships according to a white box configuration where the supplier is responsible for manufacturing activities based on buyer specifications (Le Dain and Merminod, 2014). In fact, by supplying a portion of the high-volume needs of bigger firms, small firms can specialize more and

become more competitive by capturing scale economies not possible without large-firm linkups (Etemad et al., 2001). Furthermore, SMEs may develop horizontal collaboration with large firms to enhance their competitiveness. This collaboration can support their internationalization activities by enabling them to fuse elements of international business with entrepreneurship (Dana et al., 2008). Other researchers additionally underline that SMEs can develop university-industry collaboration to carry out an innovation process. Collaborating with research institutions enables SMEs to complement their often limited internal research resources (Teirlinck and Spithoven, 2008), obtain tangible R&D outcomes (Gkypali et al., 2018), and optimize their learning (Bjerregaard, 2009).

All of these CIN arrangements enable SMEs to access external knowledge provided by the other network actors to achieve a mutually beneficial innovation goal (Van de Vrande et al., 2009). To make efficient use of new external knowledge accessible through these networks, firms need to deploy their absorptive capacity (ACAP) (Kafouros et al., 2020; Najafi Tavani et al., 2018), a multidimensional learning capability introduced hereafter.

2.2. Absorptive capacity of SMEs embedded in CINs

2.2.1. ACAP, a multidimensional learning capability

ACAP embodies a dynamic learning capability that enables organizations to improve their innovation performance (Vlačić et al., 2019) and achieve a potential competitive advantage (Fosfuri and Tribo, 2008) through consistent knowledge utilization. In this regard, organizations implement a set of practices which are structured according to distinct dimensions, each one playing a different yet complementary role (Saad et al., 2017; Zahra and George, 2002).

First, **acquisition** reflects the organization's ability to identify and access external knowledge that is potentially useful to its operations (Saad et al., 2017). It includes mastering exploration techniques and relying on interpersonal skills to source valuable knowledge from external experts (Gkypali et al., 2018; Jimenez-Barrionuevo et al., 2011). Then, **assimilation** refers to the analysis of externally acquired knowledge to assess its potential (Szulanski, 1996). It involves activities of interpretation and confrontation between new knowledge and the organization's prior knowledge (Zahra and George, 2002), and communication skills to effectively disseminate new knowledge (Camison and Forès, 2010) and extend learning to an organizational level (Saad et al., 2017). Finally, **application** or exploitation represents the mechanisms enabling organizations to leverage existing competencies and create new ones by incorporating acquired knowledge into their operations (Cohen and Levinthal, 1990). It involves retrieving knowledge that has already been created and internalized for effective use (Lyles and Schwenk, 1992). Therefore, application first requires the internalization of new knowledge by combining it with the organization's prior knowledge in order to achieve a new integrative schema

(Cohen and Levinthal, 1990). To emphasize the importance of this integration, Zahra and George (2002) separate it from the effective application of new knowledge by proposing the dimension of transformation. However, although it is an essential prerequisite for exploitation that aims to prepare knowledge for its ultimate use, Schmidt (2005:3) states that *"the transformation dimension need not be made explicit, as it is an integral part of the exploitation component"*. Hence, to make efficient use of external knowledge throughout its contribution to a CIN, an SME would implement acquisition, assimilation and application practices.

2.2.2. Two learning perspectives for an SME embedded in a CIN

Through its contribution to the CIN, an SME accesses valuable external knowledge which can be absorbed to serve two learning perspectives (Inkpen and Tsang, 2008): **reciprocal** learning representing the organization's ability to combine this external knowledge with its own in order to contribute to the network's common goal (Lubatkin et al., 2001), and **one-way** learning reflecting the organization's ability to absorb external knowledge accessible through the network to accomplish individual goals (Khanna et al., 1998; Lane and Lubatkin, 1998).

In fact, while the primary purpose of organizations that engage in collaborative relationships is to jointly exploit their capabilities so as to develop products or services that none of the actors could achieve individually (Camarinha-Matos et al., 2009), Khanna et al. (1998) and Das and Teng (2000) point out that one-way learning might also occur. Although this learning is likely to provoke a race (Hamel, 1991; Larsson et al., 1998) and induce predatory behaviour in the partners through knowledge retention (Arino and de la Torre, 1998), several authors suggest that even in the logic of mutual benefit, a balanced cooperation and learning race would be an important source of competitive advantage (Argote and Ingram, 2000; Romer, 1990; Zaheer et al., 2010). Also, when a firm intentionally seeks to source and internalize knowledge from the other network actors, its benefits in terms of innovation come at a higher rate (Srivastava et. al, 2015).

Therefore, we endorse the propositions of these authors and suggest that an SME embedded in a CIN would implement acquisition, assimilation and application practices to serve both reciprocal and one-way learnings. In addition, the exploration by the SME of the valuable knowledge derived from the other partners of the CIN to improve its own performance can be pursued as the latter exploits its knowledge to contribute to the network innovation goal (Lee and Huang, 2012). Hence, we advocate that both learning perspectives occur simultaneously (see Figure 1).

2.2.3. Two distinct phases of knowledge absorption by the SME to contribute to the CIN

The literature highlights the fact that knowledge absorption differs according to the stages of an innovation process (Barbaroux et al., 2016). In the case of collaborative innovation, two main phases requiring different knowledge management and decision-making practices (Hacklin et al., 2006) are distinguished. The first one, called the setting-up or creation stage, includes aspects of idea formalization and network structuring. During this early phase, events such as trade fairs and conferences are a crucial knowledge source to gain inspiration for the innovative idea (Van Egeraat et al., 2013) and identify potential partners (Maskell et al., 2006).

The second phase, the operation stage, is focused on the way the partners will jointly mobilize their competencies to match the market opportunities (Camarinha-Matos et al., 2009; Graça and Camarinha-Matos, 2017). It is related to the development and commercialization of the innovation and requires for instance an intensive use of boundary objects to facilitate integration of knowledge created by the contributing actors (Mäenpää et al., 2016). Hence, to absorb knowledge for reciprocal learning and accordingly contribute to a collaborative innovation process, an SME would implement acquisition, assimilation and application practices differently within the two CIN phases.

2.3. Characterization of an SME's context within a CIN

Following an in-depth literature review, we hereby introduce the different factors describing the context of an organization embedded in a CIN, which are likely to impact its ACAP.

- *External activators*

They reflect uncertain environmental conditions that drive an organization to intensively activate its ACAP (Zahra and George, 2002). Some of these external activators come from a technological evolution or a high frequency of innovation that can influence the future of the industry in which the organization operates (Bower and Christensen, 1995). In addition, Lane et al. (2006) highlight other external activators that may lead to a more intensive ACAP, including frequent changes in market trends, as well as high levels of competitiveness and regulation (Glazer and Weiss, 1993). Therefore, the more the SME is subject to such external activators, the more it needs to develop its ACAP in order to adjust to turbulence in its environment (Liao et al., 2003).

- *Internal activators*

Several internal conditions can also make an organization more motivated to acquire and integrate new external knowledge (Gluch et al., 2009). Indeed, the organization deploys an intensive ACAP in order to achieve specific performance objectives (Fosfuri and Tribo, 2008), enabling it to recover for example from an organizational crisis (Cooper and Molla, 2012) or from successive performance failures (Matthyssens et al., 2005). Accordingly, the organization is motivated to absorb knowledge in

order to initiate deep changes that redefine its strategy (Zahra and George, 2002). It is also willing to absorb knowledge through an alliance in order to strengthen its financial, social and technological capitals (Ahuja, 2000). Additionally, ACAP evolution and development is dependent on the organization's human capital (Zahra and George, 2002). This suggests that a lack of employees' technological and other skills motivates the organization to deploy its ACAP in order to complement its knowledge base (Cohen and Levinthal, 1990). Thus, the more an SME participates in the partnership to address these specific challenges, the more it needs to develop its ACAP (McAdam et al., 2010).

- *Relative prior conditions*

In the case of an organization embedded in a partnership context, the literature suggests that several characteristics of its relationships with the other actors represent prior conditions impacting its reciprocal and one-way learnings, and consequently its ACAP in such context. Previous studies showed that these relational characteristics could be defined as a function of similarities or of differences. First, the similarity of the actors' knowledge bases fosters their reciprocal (Lubatkin et al., 2001) and one-way learnings (Lane and Lubatkin, 1998), as this knowledge proximity allows a mutual appreciation of their specific know-how. Also, ACAPs for both types of learning are better served by the similarity of the actors' institutional values and routines, as this organizational fit enables learning and reduces the possible cultural clashes or other interfirm conflicts (Arino and de la Torre, 1998; Lubatkin et al., 2001). Third, the expertise of each actor must be rooted in a different informational domain (i.e. area of expertise or know-about), since redundancy would limit the benefits of the partnership for both types of learning and increase the risk of opportunism (Lubatkin et al., 2001; Mendi et al., 2020). Finally, reciprocal learning is fostered when the actors have distinct commercial objectives, as they need to collaborate in order to discover how each of them can meet their own business goals without invading the other actors' markets (Lubatkin et al., 2001). On the contrary, one-way learning is encouraged by the similarity of the actors' commercial objectives, which allows a 'learning' organization to easily find commercial applications of newly acquired knowledge from its 'teacher' partner (Lane and Lubatkin, 1998). However, the facilitating effect of this factor mainly exists when the inter-organizational relationship is intentionally established to support one-way learning, such as franchises and joint ventures (Lane and Lubatkin, 1998). In alliances that primarily serve cooperative objectives, the similarity between the commercial orientations of the actors would rather inhibit the one-way learning of the organization, since the latter would direct its efforts towards managing and anticipating the risks of this coopetition situation (Fernandez et al., 2014). Hence, the less these related prior conditions are available, the more the SME has to develop its ACAP.

- *Central roles*

Tsai (2001) argues that units with central roles in innovation networks can use new knowledge efficiently only if they deploy relevant ACAP. Indeed, powerful actors are generally efficient

exploiters of new knowledge (Hill and Rothaermel, 2003; Lawrence et al., 2005), mainly since they intensively deploy their ACAPs to make good use of knowledge available through their privileged positions (Todorova and Durisin, 2007). In a collaborative network, an actor's level of centrality is described according to different factors (Goduscheit, 2014). It depends on the organization's implication in the innovation intellectual property (IP) which grants it with a champion role, and on its strong involvement in project management, technical coordination, and interfacing with the market. Consequently, the more fundamental is an SME's role in a CIN, the more it needs to develop its ACAP.

In sum, the contextual factors resulting from our literature review represent determinants of ACAP that are not controlled by an organization embedded in a CIN. Previous studies suggest that each of these determinant factors leads to a more intensive ACAP but provide little knowledge of how they impact the ACAP dimensions. Thus, this research aims first to explore the effects of these factors on each of the ACAP dimensions of an SME embedded in a CIN to explain how they are related. Moreover, a determinant represents a causal factor, whose variations are followed systematically by variations in an outcome of interest (Bauman et al., 2002). Hence, in addition to inducing a globally more intensive ACAP, the presence of these determinants would differentiate the way an SME absorbs knowledge within a CIN. Consequently, we propose to identify the variations of an SME's ACAP according to the factors describing its context. This would enable us to generate an ACAP operationalization which emphasizes the absorption dimensions and practices that the SME should master in priority according to its context. The implications of this state-of-the art are summarized in Figure 1, which constitutes our conceptual model. In our model, we have not considered the effect of central roles on one-way learning as this contextual factor only acts at the CIN level.

Figure 1 – Conceptual model

3. Research methodology

To achieve the objectives of this study, we followed a mixed-method approach, summarized in Table 1 and explained hereafter. Accordingly, this study adheres to comprehensive research capable of handling the qualitative-quantitative dilemma to analyze the actors and their actions in managerial situations (Dana and Dumez, 2015). More particularly, the present comprehensive research aims to highlight the mechanisms underlying observed phenomena (*ibid.*). In our case, these mechanisms relate to the absorption dynamisms of an SME to enhance its innovativeness according to its involvement context in a CIN. Our unit of analysis is thus an SME embedded in a CIN.

Table 1 – Research design

3.1. A qualitative phase to develop measurement scales for the model's constructs

Although there is no existing measure for ACAP in a CIN context, we decided to perform an in-depth review of the existing ACAP multidimensional scales (Appendix A) to reap the benefits of this literature corpus for our research. From the practices proposed in previous studies, we selected an initial pool of 54 items that could be adapted to reciprocal or one-way learnings by an SME embedded in a CIN. Then, for each learning, we classified these practices according to the building blocks of our conceptual model presented in Figure 1. Since these items were transposed to the context of an SME embedded in a CIN and not specifically proposed for the latter, we combined the results of this deductive literature analysis with those of an inductive approach. This method is convenient when the conceptual basis for a construct may not result in accurate items (Hinkin, 2005). The use of inductive approaches is even more appropriate for research in small businesses as it enables analysis of the important aspects of the SME environment and leads to gaining a holistic understanding of its inherent processes (Dana and Dana, 2005).

In this respect, we used the outcomes of our literature analysis to devise an interview guide. Then, we performed 20 semi-structured interviews with 12 SMEs and their partners within three CINs (mechanical, software, medical) in France and the UK. The interviewees were mainly the SMEs' managers and other individuals (engineers, researchers, etc.) who were closely involved in the networks. To cover a wide range of absorption practices, we selected SMEs from different sectors, which collaborated with a variety of actors (SMEs, research labs, etc.) possessing diverse expertise (Appendix B). The interviews were then transcribed and qualitatively analyzed using N'Vivo, therefore enriching the literature outcomes with 28 new practices. With regard to the variables describing the SME's context within the CIN, scales were developed for their related items based on the constructs' definitions in the extant literature. The constructs in this study are summarized in Table 2. Their associated items and their sources are provided in Appendix C.

Table 2 – Summary of the constructs used in this study

3.2. A quantitative phase to propose an ACAP operational measure for the SME according to its context within the CIN

Since ACAP is context-dependent (Lane et al., 2006), the purpose of this quantitative study is to develop a measure of this capacity for an SME embedded in a CIN, considering the peculiarities of this organization's context. For this reason, we employed the PLS-SEM (partial least squares structural equation modeling) approach in a novel way as explained hereafter.

3.2.1. Data collection

The items resulting from the qualitative phase were implemented in a survey questionnaire designed in collaboration with three other researchers. Participants were asked to respond by referring to a CIN experience and rating the items on a 1-6 likert scale ranging from strongly disagree to strongly agree. The questionnaire was then pre-tested with two new academic experts and two SME managers with prior experience in CINs. This approach enables upstream management of survey biases (Forza, 2002) and helps ensuring its face validity (Holden, 2010).

To determine the most appropriate way to conduct the questionnaire, we consulted several experts in innovation management in France, namely two consulting companies and four clusters in the textile, mechanical and digital sectors. These experts pointed out that the questionnaire was not suitable to feed large-scale surveys conducted by regional and national agencies. Indeed, they underlined that its purpose and format were not in line with those of such agencies. Therefore, they advised us to carry out our empirical study separately, using their contact databases. To form our sample, we employed a judgmental sampling method (Deming, 1990) instead of probability sampling, since we did not have access to the database of SMEs embedded in CINs, nor to statistics about their involvement in such networks by sector, size, etc. A pre-questionnaire was thus addressed to the SMEs' managers listed in the experts' contact databases in order to identify SMEs with previous CIN experience. From this preliminary questionnaire, we obtained 50 responses from SMEs' managers who stated that their firms were involved in collaborative innovation projects. The full questionnaire was then sent out to the constituted sample and was also distributed by the experts to their contact databases in order to obtain more responses. The SMEs' managers were asked to complete the questionnaire themselves if they were heavily involved in the CIN or else to forward it to the member of their organization who had a key role in the CIN. From December 2016 to May 2017, we collected 88 responses. However, for the variables used in this study, 14 of the received questionnaires were omitted as they represented a high rate of nonresponse. Table 3 presents the characteristics of the respondents from the 74 remaining observations, their respective SMEs and the CINs in which they were operating. These properties convey a high diversity of respondents.

Table 3 – Sample characteristics

3.2.2. Data analysis

This research aims to propose a contextualized operationalization of the ACAP for an SME embedded in a CIN. This operational measure guides the SME towards the most relevant ACAP dimensions and practices for its context, by establishing a priority order among them. To this end, we analyzed the

model in Figure 1 using the PLS-SEM approach, which was appropriate to the nature and purposes of this study as explained below:

PLS-SEM works efficiently to estimate complex models such as the one in Figure 1, comprising many constructs, several structural path relationships and many indicators per construct (Ringle et al., 2015). This characteristic is especially relevant when small sample sizes are used (Chin, 2010), as is the case in this research (74 responses). In addition, PLS-SEM can be particularly useful for SME research where there may be restrictions on sample sizes (Sarstedt et al., 2014). This approach meets further challenges faced by small business researchers who are confronted with an increasing complexity of theories and cause–effect models, over-surveyed respondents and decreasing response rates (Benavides-Velasco et al., 2013).

Additionally, PLS was used to analyze our structural model as it is appropriate for the purposes of this study. In fact, our research aims to elaborate a predictive process prioritizing the SME's ACAP dimensions and practices according to its context in a CIN. Therefore, it encompasses two objectives: it is necessary to first understand how the factors describing the SME's context impact its ACAP, to then be able to establish the predictive process. Regarding the first purpose, we used the PLS approach to build the first theoretical propositions on how the context of an SME embedded in a CIN impacts its ACAP. This purpose is consistent with the exploratory objectives of PLS-SEM, which does not intend to confirm a theory and test already established hypotheses as is the case for Covariance Based SEM (Peng and Lai, 2012). The PLS approach is also suited to other exploratory features of this study. For instance, the variables used are described according to theoretical definitions and empirical scales supplemented by exploratory interviews. In addition, there is little theoretical support to explain the links between the blocks of variables (Rigdon, 2012). PLS-SEM is even more relevant for such early stages of theory development in small business research (Thong et al., 1996).

Regarding the second purpose, the forecasting virtues of PLS (Tenenhaus et al., 2005) made it appropriate for establishing the predictive process, prioritizing the SME's ACAP dimensions and practices according to its context in the CIN. In preference to alternative forecasting approaches, such as logistic regression (Walker and Duncan, 1967) and neural networks (Bishop, 1995), we chose the PLS approach as it is suitable for prediction with latent variables such as the constructs in our model. This method provides the opportunity to predict explained variables by performing regressions from the scores obtained through a succession of factorial analyses (Tenenhaus et al., 2005). This property of PLS enables us to predict the scores of the nine dimensions composing the SME's ACAP according to the independent contextual variables impacting them. Therefore, it is possible to rank the ACAP dimensions and practices based on the predicted scores which would guide the SME towards the most critical absorption aspects for its context.

Hence, we used the PLS approach to analyze the structural model in Figure 1 whose constructs are modelled reflectively. Indeed, these latent variables are described by several items that were formulated using literature outcomes which were completed by our field study. Therefore, these items are non-exclusive manifestations of their associated latent variables (Petter et al., 2007) that might be enriched by future studies. When analyzing such a fully reflective structural model, Chin (2010) points out that the number of responses must be more than 10 times the greatest number of links between a dependent latent variable and independent ones. Since this number is four in our model, our sample size meets this constraint and enables the use of the PLS approach. However, because of the large number of structural links to be simultaneously estimated and the small size of our sample, we chose to analyze each ACAP dimension in an independent structural model to enhance the robustness of our results. Each of these nine models includes one ACAP dimension and the constructs characterizing the SME's context that impact this dimension. To analyze each model, we used the software SmartPLS 3.0 (Ringle et al., 2015). The analysis is done in two steps: validation of the measurement model and evaluation of the structural model (Hair et al., 2013). Table 4 summarises the procedures that were undertaken to evaluate our models.

Table 4 – Analysis approach adopted

4. Results

4.1 Proposition of a measurement scale from the qualitative study

Based on the insights of the qualitative study, we developed a measurement scale of ACAP for an SME embedded in a CIN (Appendix C). Accordingly, we confirmed the possible application to our unit of analysis of several practices proposed in the extant literature. We also enriched these outcomes with 28 new practices derived from the interviews, which have never been identified in prior research that developed ACAP measurement scales. These practices were reported either directly by the SMEs that performed them, or indirectly by their partners. Some interviewees cited practices that they did not in fact put into place but believed would have been useful. Of these new practices, 26 are related to reciprocal learning by the SME, while only two support its one-way learning. Most of the 26 practices identified for reciprocal learning refer to the issue of risk resulting from joint development of an innovation in a partnership setting. For instance, during the development stage, each SME needed to be aware of the risks and benefits related to collaborating with unusual partners such as competitors, researchers or large groups (Ass-Set4): "*For the laboratories, it is mainly an academic interest, while for the SMEs it's more about having something profitable at the end. It can create lags. As a result, some editors were not really open to the idea of working with a research lab"* (SME manager in the software CIN). During the operational stage, each SME had to deploy practices to prevent risks and

promote achievement of the network's goal. For example, some SMEs needed to rapidly raise any doubts in order to avoid misunderstanding that would inhibit the accomplishment of the common project objectives (App-Dev7): *"We had a lot of disagreements and that's fine. It is generally all too easy to muddle along with a product that nobody believes in simply because everybody respects one another, and they are afraid to express what they actually think. The more disagreements we had, the happier I was. At least we did not reach a point where something was not working and someone said well, I knew that would not work"* (SME manager in the medical CIN).

The interviews also stressed the importance of differentiating between the two CIN stages to operationalize ACAP for reciprocal learning. Our results suggest that while some ACAP practices may appear similar across these phases, they target different goals. The organization of exchanges with other project actors to support the SME's assimilation within each stage could illustrate this point. In the setting-up phase, these face-to-face interactions aim to converge towards a common vision of the innovation (Ass-Set2): "*We organized common review sessions to settle on the machine requirements which we compiled in preliminary drafts and descriptive documents. Once we had discussed these issues, we started working on our contributions*" (SME manager in the mechanical CIN). In the operational stage, these exchanges are more thematically oriented and involve only the organizations that are jointly working on specific innovation development and commercialization issues (Ass-Dev2): "*There were different types of meetings: R&D meetings bringing together some of the editors, project steering meetings, and finally commercially oriented and marketing meetings"* (SME manager in the software CIN).

Finally, the interviews corroborated that an SME deploys ACAP for one-way learning simultaneously as it pursues a reciprocal learning to contribute to the common innovation goal (Acq-One6): "*So in the objectives that were a bit secondary and directly relevant to us, we made sure that our technical team would become more competent regarding the technologies that are used in the project in order to take advantage of them for our own products*" (SME manager in the software CIN).

4.2. Preliminary quantitative analysis of the dataset

Before evaluating the validity and reliability of our models we performed, using XLSTAT (Addinsoft, 2016), several initial data processing operations in order to refine the underlying factor structure. First, we managed the missing values within the 74 observations by applying the NIPALS algorithm (nonlinear estimation by iterative partial least squares) which is particularly suitable for the PLS approach (Tenenhaus, 1999). The algorithm relies on imputing the observation containing the missing value with the most probable values of the other observations. Then, we carried out Harman's single factor test to check for possible method bias resulting from the data collection approach (Podsakoff et

al., 2003). This test resulted in a 37.065% variance explained by the single factor therefore suggesting the absence of method bias.

Finally, before assessing the measurement and structural models, it is necessary to examine the constructs' unidimensionality (Urbach and Ahlemann, 2010). Unidimensionality is defined as the existence of one latent trait underlying the data (Hattie, 1985). In this respect, we assessed unidimensionality of the constructs included in our nine models by applying the tests described in Table 4. As shown in the results (Appendix D), the indicator Cent-Role4 reflecting involvement in intellectual property (IP) loaded more on the construct Int-Act (representing the SME's motivations to absorb knowledge within the network) than on Cent-Role and was therefore attached to the former. Also, the construct Rel-Prior was separated into two latent variables, Cog-Dist and Coopetition, whose items respectively express the cognitive distance between the SME and the other actors (Nooteboom et al., 2007) and the presence of coopetition between them (Fernandez et al., 2014). Indeed, the less companies share similar organizational cultures and knowledge interpretation bases, the more important is the cognitive distance between them (Nooteboom et al., 2007). Also, the more similar companies are in terms of expertise, activities and commercial orientations, the higher the risks of moving from a collaborative to a competitive relationship (Lubatkin et al., 2001). Although this separation of Rel-Prior into two new constructs increased to five the greatest number of links between a dependent latent variable and independent latent variables, the size of our sample still allowed us to implement the PLS method. After these preliminary analyses, we performed the remaining steps of PLS-SEM to assess each of our nine models independently.

4.3. Assessment of the measurement models

Within each model, we assessed the reliability of the items associated with the constructs according to the tests described in Table 4. The retained items' loadings are introduced in the diagonal values of the matrices in Appendix E. Then the results of construct reliability and convergent validity are displayed in Table 5. Finally, discriminant validity was assessed through examination of cross-loadings (Appendix E), and by verifying the Fornell–Larcker and the HTMT criteria (Table 6).

Table 5 – Constructs' reliability and convergent validity

Table 6 – Fornell-Larcker and HTMT criteria

4.4. Assessment of the structural models

Table 7 gathers the results of the structural models' assessment. We first evaluated the models' predictive accuracy, which displayed R^2 values between 0.477 and 0.714. These results exceeded the threshold of substantial R^2 (0.26), suggesting good predictive accuracy. Also, all the models were statistically significant, with F ranging from 12.410 to 37.114 and $p<0.001$. Then the quality of each model was assessed using relative GoF (goodness of fit) indices which ranged between 0.734 and 0.863, sufficiently close to 1 to suggest good model fit. Finally, the Q^2 values of the models varied from 0.219 to 0.369 and were all above zero, confirming that the models exhibit predictive relevance.

With regard to assessment of the structural paths, results show that the construct Cent-Role has a positive and significant impact on the three ACAP dimensions of the SME's contribution to the setting-up phase, as does the construct Ext-Act. This latter variable also positively impacts the application dimension of the SME's one-way learning. As for the Int-Act construct reflecting its motivations to take part to the CIN, it positively influences the SME's application dimension for its contribution to the development phase and for its one-way learning, as well as the acquisition dimension for this learning. Results also show that the construct Cog-Dist has a positive and significant impact on assimilation dimensions for the SMEs' one-way learning and for its contribution to the development phase, but also on the acquisition dimension within this phase. Finally, the construct Coopetition has a significant effect on the nine ACAP dimensions, which are all positive except for the acquisition dimension within the SME's one-way learning. We further interpret these results in the discussion part.

Table 7 – Structural model results

4.5. Predicting the relevant ACAP dimensions and practices according to the SME's context within the CIN

Analysis of the measurement models (4.3) enabled us to propose a refined measure for the ACAP of an SME embedded in a CIN. Nevertheless, since the context of such an SME induces variance in its ACAP, it is more relevant to propose an operationalization of the ACAP that is adjustable according to the SME's context within the CIN. To take this context into consideration, we first needed to understand how it impacts the SME's ACAP. In this regard, analysis of the structural models (4.4) enabled us to identify the factors describing this context, which have a significant impact regarding each dimension of the SME's ACAP. Based on these results, we tapped into the prediction virtues of the PLS approach to propose a contextualized measure of the ACAP for an SME embedded in a CIN. In this regard, after eliminating the non-significant paths depicted in Table 7, we ran the PLS algorithm again on each of our nine models to calculate the normalized weights of the remaining contextual constructs' items (Table 8) and the coefficients of the kept paths (Table 9).

Table 8 – Items' weights resulting from PLS algorithm

Table 9 – Coefficients used in the prediction equations

Based on these elements, we formulated the equations predicting each ACAP dimension's score according to the SME's context. These scores are predicted following several steps that we explain below by applying them to predict the score of the dimension Acq-Set as an example (Figure 2):

- The SME first informs its context by rating each of the items describing the contextual factors (Cog-Dist, Coopetition, Cent-Role, Ext-Act, Int-Act) on a scale of 1 (strongly disagree) to 6 (strongly agree). In our example, the SME would rate the items associated with the contextual factors impacting the dimension Acq-Set which are depicted in Figure 2.
- The contextual factors' scores are then calculated as an aggregation of their items (informed by the SME in the previous step) pondered by their normalized weights which resulted from the PLS algorithm (Table 8). In our example, the contextual factors' scores are calculated as follows:

$$Ext - Act = \begin{pmatrix} 0.107 & 0.891 & 0.001 \end{pmatrix} \begin{pmatrix} Ext - Act1 \\ Ext - Act2 \\ Ext - Act3 \end{pmatrix}$$

$$Cent - Role = \begin{pmatrix} 0.282 & 0.423 & 0.295 \end{pmatrix} \begin{pmatrix} Cent - Role1 \\ Cent - Role2 \\ Cent - Role3 \end{pmatrix}$$

$$Coopetition = \begin{pmatrix} 0.276 & 0.724 \end{pmatrix} \begin{pmatrix} Rel - Prior3 \\ Rel - Prior4 \end{pmatrix}$$

- The score of each ACAP dimension is calculated as the sum of a residual constant and the aggregation of the contextual latent variables' scores resulting from the previous step, weighted with their associated path coefficients. The constant and the path coefficients result from the PLS algorithm and are provided in Table 9. These predicted dimensions' scores naturally range between 1 and 6 (as do the items associated with the contextual factors which were informed by the SME in the first step). In our example, the score of Acq-Set is predicted according to the equation:

$$Acq - Set = 0.457 + 0.164 \times Ext - Act + 0.406 \times Cent - Role + 0.304 \times Coopetition$$

Figure 2: Illustration of the calculation model to predict the score of the dimension Acq-Set

Hence, the formulated equations predict the scores of the nine ACAP dimensions according to the SME's context, which can be ranked to identify the most critical ones for the SME. Based on the

dimensions' predicted scores, the initial weights of their associated items (Table 8) resulting from the PLS algorithm are revised by applying the following equation for each item i associated with an ACAP dimension j:

$$New\ weight_{item\ i} = \frac{Initial\ weight_{item\ i}}{6} \times Predicted\ score_{ACAP\ dimension\ j}$$

The comparison of these new weights across the items (i.e., ACAP practices) associated with the nine ACAP dimensions allows for ranking the practices and hence identifying the most critical ones for an SME to implement primarily according to its context within a CIN. Let us take the example of an SME's context for which the calculation of the predicted scores of the three ACAP dimensions within the setting-up stage results in 3 for Acq-Set, 2 for Ass-Set and 6 for App-Set. The weights of these dimensions' practices before and after the prediction of the dimensions' scores are introduced in Figure 3. The priority order of the practices associated with these three dimensions changed after the introduction of their scores, predicted according to the SME's context. Indeed, before the contextualization, the three most critical practices were (Acq-Set11, Ass-Set3, Acq-Set7), while they became (App-Set2, Acq-Set11, App-Set8) after considering the SME's context within the CIN.

Figure 3 – Example of changes within the practices' ranking for the ACAP dimensions of the CIN setting-up stage due to the introduction of the SME's context

In sum, this approach makes it possible to propose a contextualized operational measure of the ACAP for an SME embedded in a CIN. On the one hand, the prediction of the dimensions' scores identifies the most critical ones for the SME and raises its awareness regarding those it should master as a priority. On the other hand, the introduction of the dimensions' scores makes it possible to revise the weights of their associated practices which are compared across the nine dimensions to identify the most important ones for the SME's context. Thus, an order of priority is established both at the levels of the ACAP dimensions and the practices making the ACAP operational measure adjustable to the SME's context within the CIN.

5. Discussion

This study enabled understanding of the impact of an SME's context within a CIN on its absorptive capacity (ACAP). This context is described according to five factors, namely external activators, internal activators, relative prior conditions that are split into coopetition and cognitive distance, and finally central roles. These factors were found to have distinctive effects on the SME's learning

perspectives. On the one hand, for reciprocal learning, the factors' influence mainly differs according to the two stages of the CIN. On the other hand, for one-way learning, the differentiated effects of these factors are perceived at the level of the three ACAP dimensions. Furthermore, this research showed that the absorption manner of an SME embedded in a CIN necessarily changes depending on the variance induced by its context. These changes are modelled according to a predictive process which guides the SME toward the most critical absorption dimensions and practices for its context. We discuss these findings below.

5.1. The influence of the factors describing the SME's context differs according to the two stages of its reciprocal learning

Our results underline that **external activators**, reflecting highly dynamic and competitive environments (Zahra and George, 2002), induce a high knowledge acquisition, assimilation and application during the first phase of the SME's reciprocal learning. Indeed, to better exploit its capabilities for its contribution to the network innovation objective, the SME needs to be aware of the current technological and market trends in its dynamic environment (Nadkarni and Chen, 2014). Also, an assimilation of the risks and benefits of joining a CIN is needed to assess the collaboration relevance for responding to the SME's environmental dynamism (Osland and Yaprak, 1995). The presence of external activators would even compel the SME to make substantial efforts in organizing its contribution to the network to ensure that the defined performance objectives and business model are aligned with the level of its environment dynamism (Heij et al., 2014). As for the SME's ACAP during the second phase of its reciprocal learning, none of the dimensions is significantly impacted by external activators. While the setting-up phase defines the SME's collaboration strategy to participate in the CIN, the development phase represents the way it operates to accomplish its defined objectives. The strategic nature of the first phase and the operational nature of the second one (Camarinha-Matos et al., 2009) could explain why external activators only impact the SME's ACAP during the network setting up, since environment turbulence primarily induces changes at the strategic level (Johnson et al., 2003).

Concerning the **central roles** factor, we found that the more the SME has a central position within a CIN, the more it will deploy an intensive ACAP during the network setting-up phase. During this stage, boundary actors play a critical role in investigating the innovation environment in order to identify inspirational ideas (Jeppesen and Laursen, 2009) and actors possessing critical competencies for the project (Goduscheit, 2014). They are also heavily involved in organizing regular exchanges with all the actors in the CIN (Hauschildt and Schewe, 2000) to set it up and formalize the innovative idea. In addition, they have to define the project planning and set up the collaborative techniques (Gemünden

et al., 2007) to manage the interfaces between the network actors. As for the SME's contribution to the innovation development phase, our results suggest that its centrality has no significant effect on its ACAP. An explanation of this result could be that, during the operational stage, each actor acquires knowledge for its own responsibilities and interacts mainly with the partners at the interface of its contribution. Exchanges gathering the whole network which would require high coordination are rarely needed, as was underlined by an SME manager in the qualitative phase of this study: "*We have regular partner meetings and also mandatory meetings with the organization that funds us. Everyone gives presentations on how we are progressing. We do not drag people into big meetings where everyone is present just for the sake of it*" (SME manager in the medical CIN).

We found that there is no significant effect of the SME's **internal activators** on its ACAP for both stages of its reciprocal learning except for the application dimension in the CIN operational phase. The non-significance result for the three ACAP dimensions within the setting-up phase could be explained by the fact that, at the early stages of the project, the SME's own objectives are still not clearly formalized, as they can be redefined to meet the common network goals or to reap potential benefits of which the SME was not aware before its interactions with the identified partners. As for the SME's acquisition and assimilation for its contribution to the CIN operational stage, the non-significance result of internal activators regarding these dimensions can be accounted for by the fact that they do not directly induce benefits, but rather represent intermediate stages to meet the SME's objectives. This is not the case for the application dimension in the CIN operational phase, which requires from the SME substantial efforts to react on its internal activators by finalizing its contribution to the project, efficiently exploiting knowledge to meet its IP objectives or, more generally, achieving highly demanding financial and strategic goals (Ahuja, 2000).

Cognitive distance was found not to have a significant effect on the SME's ACAP during the setting-up phase. This could be explained by the fact that, at this stage, the SME does not need to understand and integrate advanced technical knowledge from the other network actors. Their interactions focus on organizing the CIN, with knowledge related to project management, which may need less cognitive alignment. Another explanation may be related to a bias resulting from the respondents' representation of the knowledge type that they considered when they replied. This suggestion is supported by the results of our qualitative phase. Indeed, most of the practices resulting from the interviews (Appendix C) show that respondents naturally think primarily about technological knowledge, probably because most participants in CINs have a technical background. During the operational stage, we found that the cognitive distance has a positive and significant impact on acquisition and assimilation dimensions while this factor does not influence knowledge application. The more the knowledge bases and fundamental values (Nooteboom et al., 2007) are different between the SME and its partners, the more it needs to be informed about and to assimilate their constraints and requirements

in order to foster its contribution to the common innovation goal. Then the SME and its partners apply the knowledge according to what they have commonly defined in the previous dimensions. Most of the time, the innovation in the CIN is split into several sub-products. Each of them can be finalized by one partner in the CIN corresponding to an efficient division of tasks (Islam et al., 2018). Therefore, this autonomous application of knowledge does not require a cognitive proximity between the partners.

Concerning the **coopetition** factor, this study's findings provide evidence that collaborating with potential competitors who possess similar competencies and commercial orientations is the major factor that influences all the ACAP dimensions of an SME embedded in a CIN, both for the setting-up and development phases. As innovation requires combining different types of knowledge (Taylor and Greve, 2006), firms operating in an environment with poor knowledge diversity are compelled to strengthen the width and breadth of knowledge acquisition to accomplish innovating outcomes (Laursen and Salter, 2006). Coopetition was also found to have a positive significant effect on the SME's assimilation dimensions for both stages of its reciprocal learning. In fact, the SME needs to assess the risks and benefits of coopetition (Galkina and Lundgren-Henriksson, 2017; Ritala, 2012), before deciding to join a network with potential competitors. During its contribution to the innovation development, the SME intensifies its assimilation efforts to appreciate the propositions of its competitors which may be better than its own ways of using knowledge, and therefore overcome the narrow-mindedness that can occur in a coopetitive situation (Le Roy and Fernandez, 2015). Besides, coopetition would encourage the SME to provide more efforts in knowledge application during the upstream phases of the project, by contracting its risky relationships with other actors (Bouncken et al., 2015) and by establishing a business model that respects everybody's interests. These efforts are also needed for efficient knowledge application during the CIN operational stage to prevent the SME from having its market invaded by competitors (Lubatkin et al., 2001).

5.2. The influence of the factors describing the SME's context differs according to the three dimensions of its one-way learning

External activators were found to have a determinant effect only on the SME's application dimension while they had no impact regarding the SME's acquisition and assimilation for its one-way learning. Indeed, firms operating in highly dynamic environments are required to explore all the possibilities of applying learnt knowledge likely to improve their performance (Jantunen, 2005), by initiating innovation projects (Christensen et al., 1998) and restructuring their organizational capabilities to favour strategies enabling them to sustain a long-term performance (Zahra and George, 2002). Therefore, they won't focus on initiatives mostly intending to increase their stock of knowledge, as these strategies are only beneficial in the short term (Denicolai et al., 2016).

Our results suggest that high levels of **internal activators** mostly compel an SME to deploy its ACAP in order to acquire and apply external knowledge for its one-way learning. In fact, the SME's willingness to strengthen its technical capital and address strategic challenges incites it to be particularly attentive to acquiring potentially valuable knowledge for its organization (Ahuja, 2000). Such efforts are also needed to quickly apply the acquired learnings and capitalize on its contribution to the project. In fact, the more the SME's long-term performance objectives are challenging, the more it will implement systematic transformation routines and change conduct practices (Zahra and George, 2002) to foster the application of newly acquired knowledge.

As for **cognitive distance**, our findings show that this factor only induces high levels of assimilation. Indeed, new knowledge acquired by the SME through the CIN can embody heuristics that differ considerably from those used by the organization (Leonard-Barton, 1995). Thus, intensive interpretation and exchanges within the SME are needed in order to understand the potential of this new knowledge for its own organization and align it with its frame of reference (Mendi et al., 2020; Zahra and George, 2002).

Finally, **coopetition** has a negative significant effect on the SME's acquisition dimension and positively impacts the two other dimensions for its one-way learning. In fact, the more similar the SME's expertise with regard to the other network actors, the less this organization is motivated to struggle for knowledge acquisition, as this situation does not bring new complex or attractive knowledge requiring special effort. The absence of such valuable knowledge is also due to the fact that companies that are in a coopetition situation are not enticed to share their knowledge and may deploy strategies of asymmetric or hidden information when they consider the knowledge they possess to be highly valuable (Lubatkin et al., 2001). The positive effect of coopetition on the SME's assimilation and application stems from its need to quickly find and pursue valuable usages of learnings acquired through the project, in order to anticipate or react to competition (Powell, 1998), especially when the partners have a substantial capacity to appropriate new knowledge and access to markets.

5.3. The primary absorption dimensions and practices change according to the context of an SME embedded in a CIN

This study established a model that predicts a priority order of the ACAP dimensions and of the practices across these dimensions, considering the peculiarities of the SME's context within the CIN. The SME should be aware of this ranking in order to properly absorb knowledge within the CIN and achieve successful reciprocal and one-way learnings (Das and Teng, 2000; Lubatkin et al., 2001). This research thereby converges towards the studies that emphasize the dynamic nature of ACAP (Zahra

and George, 2002) and learning (Eisenhardt and Martin, 2000; Zollo and Winter, 2002), which must be properly managed according to organizational environments in order to achieve sustained benefits.

In the same vein, this study provides elements of response to the gap identified by Flatten et al. (2011), who emphasized the need to explore how the relative importance of each ACAP dimension would differ according to an organization's contextual setting. In this respect, to efficiently achieve reciprocal and one-way learnings, the SME will absorb knowledge differently depending on the characteristics of its partners, its role within the network as well as its internal and external environments.

6. Conclusion

6.1. Theoretical implications

Although CINs constitute a key organisational mode for SMEs' innovation and competitiveness (Lee et al., 2010; Tsai, 2009), no research had explored how these organizations can implement ACAP in such a setting. Thus, this study covers this gap by proposing an operationalization of the ACAP adapted to the context of an SME embedded in a CIN. As such, it presents several theoretical contributions. First, this research contributes to the field of work developing operational measures of ACAP. This study follows a mixed method to propose a contextualized operationalization of the ACAP for an SME embedded in a CIN. Existing research hardly used such a method to investigate ACAP (Bröring and Leker, 2007; Flatten et al., 2011; Murovec and Prodan, 2009; Saad et al., 2017; Sedoglavich et al., 2014). In addition, among these studies, only that of Flatten et al. (2011) proposed a multidimensional operationalization of this construct. Our research stands out by the development of an operational assessment of this capacity in a CIN context which, additionally, is contextualized according to the factors impacting the ACAP.

Second, this research underlines that SMEs pursuing an open innovation strategy develop ACAP to fulfil reciprocal and one-way learnings. Thus, it provides some insights to complete the lack of knowledge about ACAP in the context of SMEs as highlighted by Hossain et al. (2016). Through their participation in a CIN, SMEs develop their capacity to absorb external knowledge in order to co-develop and commercialize an innovation with the other CIN actors (Ferreras-Méndez et al., 2016). This open innovation strategy also helps them to develop their own ACAP by transforming external knowledge into internal innovation development and commercialization so as to improve their technological and financial performances (Rothaermel and Hess, 2007). For both reciprocal and one-way learnings, our study shows that a coopetitive environment will increase the companies' efforts to deploy their ACAP, regardless of their level and type of expertise.

The last contribution is of a methodological nature. We used the PLS method by drawing upon its forecasting features (Joreskog and Wold, 1982) to establish a predictive process that explains the activation of ACAP dimensions and practices for an SME embedded in a CIN according to the contextual determinants of ACAP. While researchers often emphasize that predictive capabilities are a strength of the PLS approach, methodological advances and applications in this direction are rare (Carrion et al, 2016). To our knowledge, none of the studies in the management field focusing on forecasting used this approach. Accordingly, this research provides a methodological example for establishing a forecasting model based on PLS.

6.2. Managerial implications

Several managerial implications can be derived for this research. Firstly, by proposing an ACAP measure adapted to the context of their participation in CINs, SMEs can be guided towards the most critical absorption dimensions and practices they need to master. Accordingly, these practitioners would be able to determine where additional investments should be made to upgrade and improve the use of ACAP. In this regard, this contextualized ACAP measure can be used upstream of an SME's contribution to a CIN, to anticipate its capability gap and implement the necessary improvement actions that would foster its reciprocal and one-way learnings. The SME can also mobilize this instrument to evaluate its ACAP during its participation in a CIN in order to take a step back from its current practices and set up the relevant corrective actions.

Secondly, this contextualized ACAP measure could be useful to manage an SMEs' network efficiently. Indeed, carrying out an ACAP evaluation by each participating SME would allow the network to better configure itself in order to accomplish the common innovation goal. In this regard, the tasks and responsibilities are distributed according to the capabilities of each actor, e.g., SMEs that are best suited to boundary-spanning roles. This early assessment by the initial network also allows the identification of new actors to fill the CIN's deficit regarding certain practices. For example, if none of the present actors has expertise in CIN coordination, they can call on an open innovation intermediary (Kokshagina et al., 2017) able to stimulate the collaboration and solve technical issues in a networked configuration. Furthermore, such assessment can be performed during the development phase to identify the risks of the current network structure and review it if necessary. This network-level evaluation is of particular interest for SMEs that are used to innovating together, as it would generate learnings to better prepare and carry out their future common projects.

Thirdly, our results provide important insights into channels whereby government policies might foster innovation. Indeed, we showed that SMEs can benefit from their CIN experience to overcome the difficulties they usually face in investing and developing ACAP alone (Rojas et al., 2018; Saad et al.,

2017; Tojeiro-Rivero and Moreno, 2019). This suggests that policy makers should propose instruments stimulating the participation of SMEs in CINs, which would enhance their ACAP and enable them to develop future innovations either on their own or in an open innovation setting (Leckel et al., 2020; West et al., 2014). These investments in policy instruments would even bring further benefits for the innovation landscape. In fact, the innovation outcome from a CIN may be naturally superior due to the multidisciplinary knowledge of the CIN actors (Lee et al., 2010). Therefore, policy makers should establish regimes supporting the quality of this collaborative innovation but also of the processes it involves (Veak, 2006). In addition, innovation relies on technologies acting in relation with a host of social and cultural factors (Smith and Stirling, 2017). Indeed, the use of technologies by given groups and for particular purposes is assumed by those involved in their development (Akrich, 1992). This suggests that the established regimes should leverage this socio-technical property of innovation to foster its diffusion (Berkhout et al., 2004). Accordingly, policy makers might propose a framework that supports innovation democracy by connecting and involving actors who are capable of challenging the direction of innovation (Smith and Stirling, 2017). These actors include organizations with diverse technological, social and cultural backgrounds, but also socially embedded end users likely to adopt the developed innovation, as they would stimulate market readiness (Berkhout et al., 2004).

7. Limitations and future research avenues

This empirical study is not without limitations. First, the sample only gathers industrial SMEs. Supplementary research would be required to assess the degree to which the proposed operational ACAP measure holds in large groups. Indeed, compared to SMEs, bigger companies focus mainly on R&D in open innovation efforts (Lee et al., 2010), possess more technological assets and a greater ability to access external resources (Narula, 2004).

Secondly, it would be relevant to extend the ACAP measure developed in this study by performing further analyses in order to conceive a measurement scale for this construct that is validated according to Churchill's paradigm (Churchill, 1979). Indeed, the nonexistence of such an ACAP measurement scale for an SME embedded in a CIN compelled us to proceed to a qualitative phase in order to propose items describing this construct, and then to a quantitative approach in order to refine them. Although the measure developed enabled the fulfilment of the prediction purposes of this study, further research might complement the two steps we achieved by conducting a confirmatory analysis using data collected from a new sample of respondents in order to generate a measurement scale following the recommendation of Churchill (1979). This last step would provide the means to firmly decide on the significance of some items and structural paths that were eliminated in this study.

Third, further quantitative studies could help overcome some of the limitations of our judgemental sample. Due to the impossibility of relying on a probabilistic sample, we used a judgemental approach to identify respondents and were careful to manage its biases throughout data collection and analyses. Although the final sample contains a high diversity of respondents, it is not guaranteed to be representative of the population studied. Therefore, caution should be exercised when generalizing from our findings to specific SME contexts. Future research might explore the significance of our model under various SME characteristics.

Fourth, since our unit of analysis was an SME embedded in a CIN, the respondents were asked to complete the survey by assessing their ties with regard to the network as a whole. Hence, we did not manage to appreciate the differentiated effects of dyadic relationships within the same CIN. We therefore encourage future research on this topic to explore how an SME can develop different relative ACAPs (Land and Lubatkin, 1998) depending on the nature of each of its bilateral relationships. This would also complete the work of Mei et al. (2019) who investigated SMEs' ACAP in business ecosystems and showed that an SME develops different ACAPs with two types of partners, namely prominent organizations and service intermediaries.

Finally, to facilitate the appropriation of this study's results by practitioners, a maturity tool integrating the identified practices and the developed prediction process could be designed. Maturity tools are assessment supports which raise an organization's awareness regarding its strengths and weaknesses in order to initiate the necessary improvement actions (Maier et al., 2012). Such a tool would therefore be adequate to guide the SME towards the critical absorption aspects for its context. Future research would define the structure of this tool and the maturity criteria against which the SME should be judged. In addition, an action research process could be adopted to align the tool with the SMEs' reference frame, assess its usefulness and demonstrate the transferability of the inferences resulting from the mixed method used in this study (Venkatesh et al., 2013).

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Figures

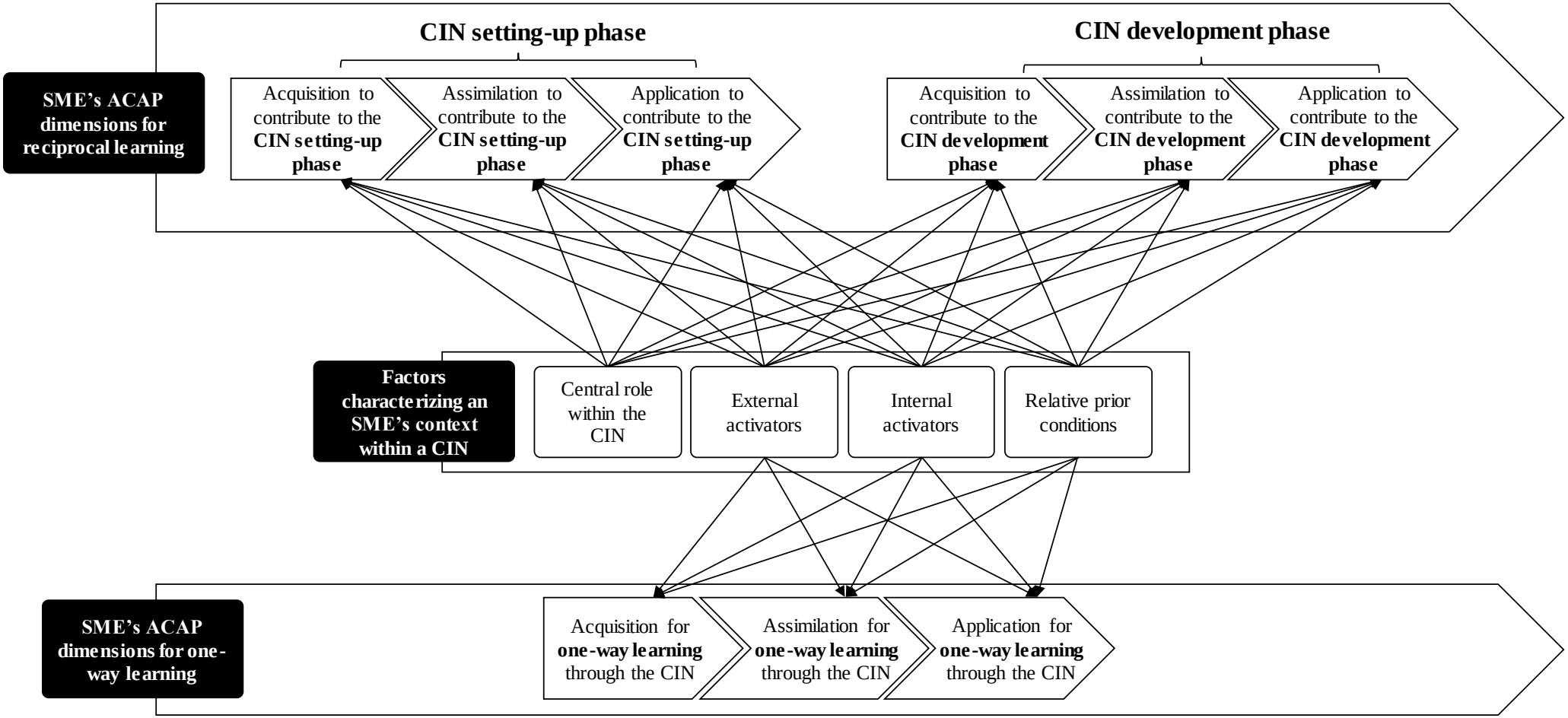

Figure 1 – Conceptual model

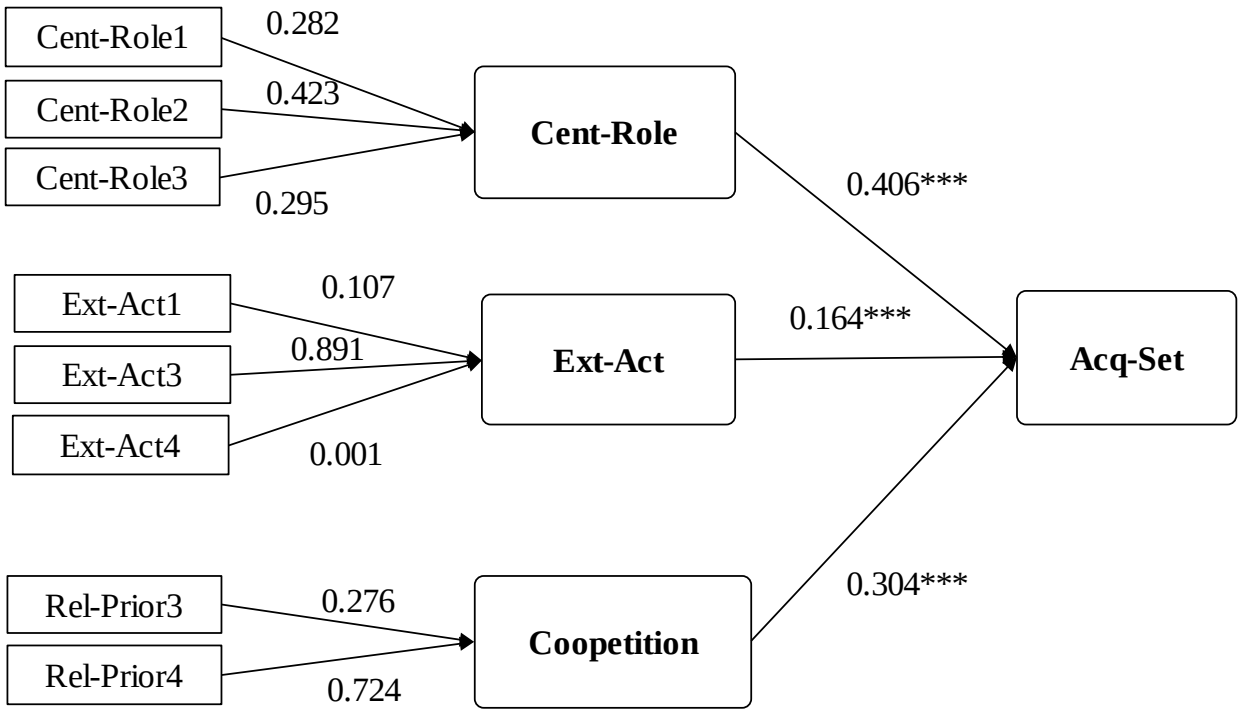

Figure 2 – Illustration of the calculation model to predict the score of the dimension Acq-Set

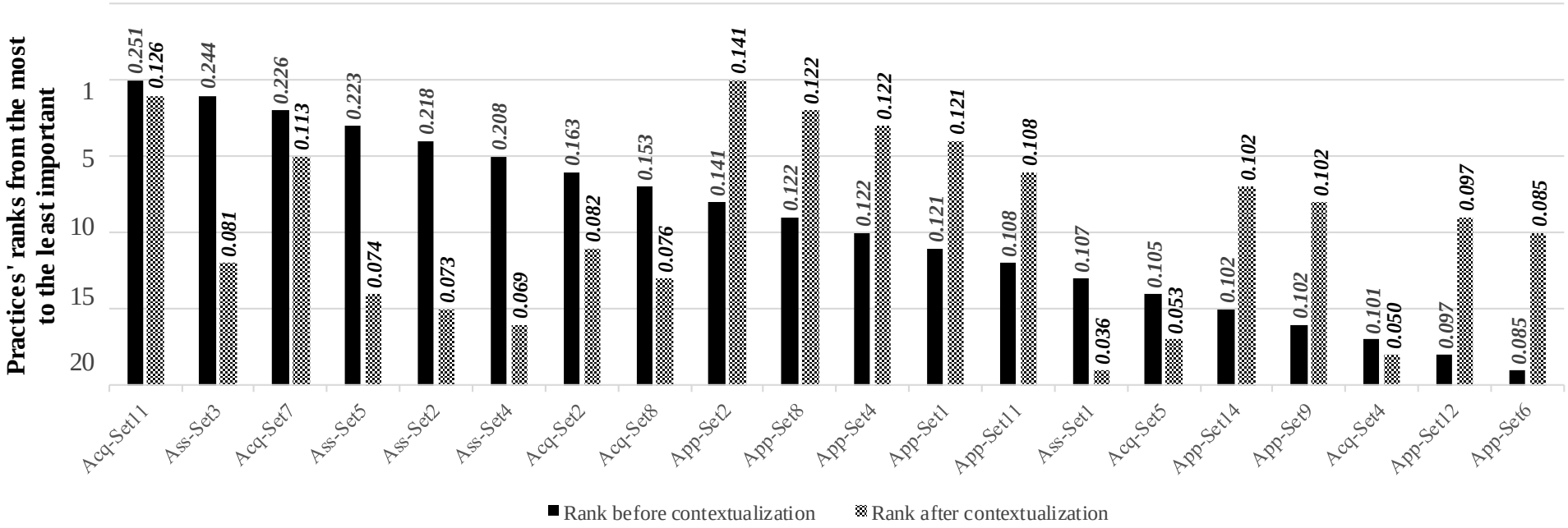

Figure 3 – Example of changes within the practices' ranking for the ACAP dimensions of the CIN setting-up stage due to the introduction of the SME's context

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