SMES CONTRIBUTING TO COLLABORATIVE NETWORKS FOR INNOVATION: A MATURITY ASSESSMENT OF THEIR ABSORPTIVE CAPACITY

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Abstract: *Technology SMEs increasingly engage in Collaborative Networks (CNs) to access valuable knowledge for innovation. By deploying their absorptive capacity (ACAP), they attempt to integrate this new knowledge necessary for their contribution to CNs. This ACAP varies according to the SME's embedding context, for instance in terms of roles, environmental turbulence, and cognitive distance with the network members. Despite ACAP's importance for such SMEs, no study guides them towards the relevant way to deploy it for their participation in the common innovation goal. Hence, we propose a grid-based maturity model allowing technology SMEs to evaluate their ACAP considering their embedding contexts in CNs. We follow a Design Science approach using both qualitative and quantitative methods to plan and develop the model. We provide theoretical contributions on the nature of these SMEs' ACAP and practical implications on how to deploy it to reach the innovation goal.*

Keywords: technology SMEs; collaborative networks; collaborative innovation; absorptive capacity; maturity models.

Resumo: *As PMEs de tecnologia estão cada vez mais participando de Redes Colaborativas (CN) para acessar conhecimento valioso para inovação. Ao empregar sua capacidade de absorção (ACAP), eles tentam integrar esse novo conhecimento necessário para sua contribuição para as CNs. Este ACAP varia de acordo com o contexto de incorporação do SME, por exemplo, em termos de papéis e distância cognitiva com os membros do CN. Nenhum estudo os orienta para a forma adequada de implementá-lo para sua participação no objetivo comum da inovação. Portanto, propomos um modelo de maturidade baseado em grade que permite que as PMEs de tecnologia avaliem seu ACAP levando em consideração seus contextos de integração CN. Seguimos uma abordagem de Design Science para planejar desenvolver o modelo. Fornecemos contribuições teóricas sobre a natureza do ACAP para essas PMEs e as implicações práticas sobre como implementá-lo para atingir o objetivo da inovação.*

Palavras-chave: PME tecnológicas; redes colaborativas; Inovação colaborativa; capacidade de absorção; modelos de maturidade

Resumen: *Las pymes tecnológicas participan cada vez más en redes colaborativas (CN) para acceder a conocimientos valiosos para la innovación. Al desplegar su capacidad de absorción (ACAP), intentan integrar este nuevo conocimiento necesario para su contribución a las CN. Este ACAP varía según el contexto de incorporación de la pyme, por ejemplo, en términos de roles y distancia cognitiva con los miembros del CN. Ningún estudio les orienta hacia la forma pertinente de implementarlo para su participación en el objetivo común de innovación. Por lo tanto, proponemos un modelo de madurez basado en grid que permite a las pymes tecnológicas evaluar su ACAP teniendo en cuenta sus contextos de integración en las CN. Seguimos un enfoque de Design Science para planificar y desarrollar el modelo. Brindamos contribuciones teóricas sobre la naturaleza del ACAP de estas pymes y las implicaciones prácticas sobre cómo implementarlo para alcanzar el objetivo de innovación.*

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Palabras clave: pymes tecnológicas; redes colaborativas; innovación colaborativa; capacidad de absorción; modelos de madurez

1 INTRODUCTION

Technology innovation helps technology SMEs differentiate themselves from competitors and thrive in increasingly international dynamic environments. However, the lack of resources and highly specialized and diverse knowledge to carry on the whole innovation process can hinder these firms' innovation efforts (Liu & Hsiao, 2019). Hence, they rely on open innovation alternatives especially by participating in collaborative networks (CNs), usually through trade associations and chambers, involving heterogeneous actors that work together to achieve a mutually beneficial goal. This open innovation strategy has become even more critical for organizations to enhance their resilience in times of crisis (Ramezani & Camarinha-Matos, 2020) such as the COVID-19 pandemic. CNs enable technology SMEs to pool their resources with other actors and share the risks and benefits inherent in the innovation development. Most importantly, they facilitate access to knowledge complementary provided by these actors to jointly develop innovations that none of them could achieve individually (Liu & Hsiao, 2019).

Nevertheless, this collective blending of knowledge and skills to generate mutually beneficial innovations requires coordination practices to capitalize on the complementarities between the actors while protecting the key expertise of each from possible leaks (Lubatkin et al., 2001). These challenges are more significant for technology SMEs whose lack of resources prevents them from dedicating a team to the CN to better contribute to innovation. In addition, their competitive positions may be jeopardized when they collaborate with large powerful firms that can easily appropriate the key knowledge of these SMEs (Hallen et al., 2014). Despite the substantial literature on CNs, no study guides technology SMEs towards the appropriate approach that would enable them to efficiently integrate and use new knowledge accessible via a network to contribute to the common innovation goal.

To cover this gap, we rely on the concept of Absorptive Capacity (ACAP) in order to uncover the peculiarities of new knowledge integration by technology SMEs in this interorganizational innovation setting. This learning capability refers to a firm's ability to identify relevant external knowledge, assimilate it, and apply it to commercial ends (Cohen & Levinthal, 1990). Several researchers operationalize it through measurement instruments developed for intraorganizational contexts (e.g., Ter Wal et al., 2011) or interorganizational long-term alliances of large firms (e.g., Thuc Anh et al., 2006), but none for technology SMEs' innovation within CNs. Extant measures are not suitable to our unit of analysis as they overlook the contingency incidence of the CN context on ACAP, in terms of limited temporality (Sydow & Braun, 2018), SMEs' nature, the partners' difference of structures and cultures, etc. (Lubatkin et al., 2001).

We follow a Design Science approach to develop a maturity model assessing ACAP of SMEs for their contribution to innovation in CNs. Maturity models raise firms' awareness of best practices,

identify trouble spots, and stimulate improvement activities (Maier et al., 2012). The proposed model will guide the SME towards the practices most suitable to its CN embedding context. For this propose, we design an approach to predict such practices considering ACAP's contextual determinants such as the SME's role in the CN, or its cognitive distance from the other actors (Nooteboom et al., 2007).

2 THEORETICAL FOUNDATIONS

2.1 COLLABORATIVE NETWORKS FOR SMES' INNOVATION

Collaborative networks (CNs) refer to "*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, p. 49). To reach common innovative goals, the network actors reciprocally learn together through sharing and generation of knowledge (Lubatkin et al., 2001) across two distinct stages, each one requiring specific knowledge management practices (Hacklin et al., 2006). The early setting-up phase implies an intensive participation in fairs to gain inspiration for the innovative idea and identify complementary partners (Van Egeraat et al., 2013). The development stage requires intensive exchanges within the network, for instance using boundary objects to facilitate the joint integration of knowledge to develop and commercialize the innovation (Mäenpää et al., 2016).

CNs are considered as a fundamental open innovation alternative for a technology SME to share with other partners the financial and development risks of the innovation process and to balance its relative dependence and power in negotiation with buyers. These networks also enable SMEs to overcome their lack of knowledge and skills to manage the entire innovation process (Smolander et al., 2020) by accessing complementary knowledge for innovation from other CN actors. An SME would then remain focused on developing specific expertise in the few technological areas that provide it with a stable market position, and at the same time access new external knowledge to generate an innovation with a greater outreach and more sustained benefits (Lee et al., 2010).

2.2 ABSORPTIVE CAPACITY

To make an efficient use of external knowledge for innovation in CNs, firms need to deploy their absorptive capacity (ACAP). ACAP refers to a firm's ability to recognize the value of new information and knowledge, assimilate it, and apply it to commercial ends (Cohen & Levinthal, 1990). It is a dynamic learning capability enabling firms to align with their turbulent environments by making an efficient use of external knowledge to improve performance (Najafi Tavani et al., 2018). In an interorganizational context, ACAP also embodies the degree to which an organization is capable of learning from its partner to improve performance (Omidvar et al., 2017).

Most empirical research mobilizes the ACAP conceptualization of Zahra and George (2002) to measure it. They conceive it as a combination of new knowledge acquisition, assimilation, transformation, and exploitation dimensions. For the studied SMEs, we consider the three following dimensions. Acquisition reflects the organization's ability to identify and access externally generated knowledge that is critical to its operations. Assimilation refers to the analysis of externally acquired knowledge to assess its potential. Application or exploitation refers to the firm's ability to leverage existing competencies or to create new ones by incorporating acquired knowledge into its operations (Cohen & Levinthal, 1990). We did not include the transformation dimension as it conveys a firm's efforts to create perceptual schemas from the newly acquired knowledge that will be exploited for long-term value creation (Zahra & George, 2002). Hence, it is not consistent with the ACAP examined in our study which focuses on the SME's contribution to achieving the temporary network's innovation goal.

ACAP of a firm in a CN is subject to several contextual determinants that influence its deployment. First, external activators such as rapid technological evolution would drive an organization to intensively activate its ACAP to align with its environment's turbulence (Zahra & George, 2002). Second, internal activators conveying specific performance objectives such as strengthening the firm's technological, social, and financial capitals through the network can trigger it to acquire and integrate new knowledge (Gluch et al., 2009). Third, units with central roles in innovation networks efficiently use new knowledge only if they deploy an intense ACAP (Tsai, 2001). Fourth, a firm in a reciprocal learning partnership such as CNs, is required to deploy an intense ACAP when its cognitive distance regarding the other actors is substantial; and when it is in a coopetitive network with members who hold close expertise and commercial orientations that may generate liabilities (Lubatkin et al., 2001).

3 RESEARCH DESIGN

We propose to develop a maturity model measuring ACAP for an SME's contribution to innovation in a CN. Maturity models are continuous improvement instruments assuming that when processes or activities are defined, managed, and executed effectively, they will lead to better performance (Dooley et al., 2001). The first type of these models refers to CMMI that was developed by Software Engineering Institute (SEI) to certify organizations' maturity for delivering a software compliant to the requirements. Its certifying usage has been extended to institutionalized processes other than computer programming. The second type is maturity grids that are designed to communicate good practices in a simple and efficient way (Maier et al., 2012). Grid-based maturity models are defined in relation to the evaluated topic and are less expensive, and less time-consuming compared to CMMI. This helps quickly measure the gap between an organization's current practices and the ones to target, thereby making them adequate for SMEs in the early phases of CNs.

We follow the design science approach suggested by Maier et al. (2012) to develop our maturity model. This approach consists of four phases: planning, development, evaluation, and maintenance. Our

investigation covers the two first phases. We are currently proceeding with the model's evaluation by testing it with real-life case studies. The maintenance phase is related to the continuous upgrade of the model as it is applied. The model's design requires determining the key process areas (KPAs) that are mutually exclusive and collectively exhaustive to describe the evaluated object. Each KPA is defined through associated practices, implemented collectively, to satisfy a set of important improvement goals. KPAs are described at different levels of performance. The highest maturity level is where the KPA's practices are efficiently applied and culturally rooted. We complement this approach with a quantitative study to contextualize the ACAP of an SME for its innovation in a CN. This capacity varies according to several contextual determinants. Hence, the ideal maturity level of ACAP KPAs and practices should be defined according to the SME's context to guide this firm towards those it should master primarily.

3.1 PLANNING

In this phase, we decide on the model's audience, its aim of assessment, its scope, and the criteria for its successful application. To inform these elements, we performed a literature review on SMEs' collaborative innovation, complemented by 10 exploratory semi-structured interviews as recommended by Maier et al. (2012). We interviewed four CEOs of technology SMEs in France that have operated in several CNs within the multimedia and textile sectors. We also interviewed two French experienced innovation management consultants used to conducting capabilities' assessments through maturity models and four representatives of French industrial clusters from sectors with different technological intensities, who frequently support collaborative innovation projects. The interviewees confirmed that collaborative innovation is a major focus of European policymakers to capitalize on synergies between organizations in an environment where knowledge is highly scattered.

For the model's audience, they recommended addressing the key members of the SME's project team including the CEOs, as they are involved in the strategic and operational aspects of innovation projects. The model should aim to quickly identify the SME's capabilities' strengths and gaps since the CN early phases. For the scope, the maturity grid must be applicable to technology SMEs embedded in CNs regardless of their sector and of the CN configuration. Finally, the model's application is successful when the SME perceives it as useful, usable, and complete to guide improvement (Moultrie et al., 2007).

3.2 DEVELOPMENT

The development phase defines the architecture of the maturity model namely the KPAs, the maturity scale, the content formulation, and the administration mechanism. To inform these elements, we combined an in-depth literature review and three empirical sources. First, 19 semi-structured interviews were conducted in three different CNs in the mechanical, software, and medical sectors. These CNs involved 13 SMEs embedded in various collaboration configurations considering the ACAP contextual determinants. We interviewed key project team members within these SMEs and within some

of their partners, resulting in 23 hours of recordings that were transcribed and grammatically sub-divided to enable their thematic analysis with NVivo software (Taylor et al., 2015). We reached semantic saturation by the 16th interview. Second, we organized two focus groups with experts including researchers in knowledge management and practitioners with prior experience in CNs to discuss the interviews' outcomes and define the appropriate architecture of the maturity model. Consequently, we consolidated the practices stemming from the interviews and/or highlighted by the group members that convey similar themes. Third, we performed a quantitative analysis to elaborate the contextualization approach of the maturity model. The resulting model's architecture is explained below.

First, our literature review underlined six exclusive dimensions that holistically describe the SME's ACAP, and whose accuracy as KPAs was confirmed following the empirical process. They refer to knowledge acquisition, assimilation, and application by the SME to contribute to the network's setting-up then to its development stage. Second, to define the maturity of ACAP, we reviewed several studies around maturity models and accordingly selected two criteria considering the properties of the SME's ACAP, namely capability and willingness. The relevance of these criteria for our unit of analysis and their associated scales were discussed and validated during the focus groups. Third, to formulate the model's content, we applied a hybrid approach recommended for concepts with a cognitive rather than a technical connotation as is the case of ACAP (Cohen & Levinthal, 1990). The approach consists in describing the KPAs using a set of questions formulated as an expression of best practices (Fraser et al., 2002). The respondent scores the KPA's practices on a Likert scale ranging from 1 to n, where n is the highest maturity level of the KPA. To define these good practices, we combined the outcomes of an in-depth review of the existing ACAP multidimensional measures, those of the interviews, as well as the outputs of the focus groups. Fourth, we chose an interactive administration mechanism in the presence of a moderator with the participation of the SME's representative and eventually key members of its project team. In both focus groups, this mode was recommended because it is more engaging and stimulating for the participant than individually informing the model.

Finally, as the SME's ACAP varies according to its embedding context in the CN, we designed a prediction process to guide the SME's efforts toward the most important KPAs and practices for its context. We used PLS (partial least squares) algorithm, because of its forecasting virtues (Tenenhaus et al., 2005), under SmartPLS4.0 to quantitatively analyze 74 responses of a survey conducted with SMEs innovating within CNs. PLS allows prediction with latent variables by performing regressions from the scores obtained through a succession of factorial analyses. Accordingly, the contextual determinants and ACAP practices were refined (Appendix 1) and the prediction equations were formulated.

4 RESULTS

4.1 PRACTICES ASSOCIATED WITH THE ACAP KPAS

56 practices associated with the six KPA were determined following our literature review. 31 were adjusted from the extant ACAP multidimensional measures proposed in contexts other than the one investigated in this study. The interviews confirmed some of these adapted practices and highlighted 25 new ones. Most of these newly identified practices refer to the issue of risk management throughout both stages of a CN (Appendix 1). The focus groups confirmed the semantic saturation of the absorption practices resulting from the literature and the interviews.

Finally, we performed factor analysis to eliminate the non-significant practices, which resulted in retaining 38 absorption practices (Appendix 1). This required assessing the practices' reliability based on a bootstrapping procedure with 500 sub-samples, then evaluating the constructs' convergent validity in terms of AVE, and their reliability with Dillon-Goldstein's Rho and Cronbach's alpha. Regarding discriminant validity, all the constructs verified the Fornell-Larcker and HTMT criteria.

4.2 PREDICTION PROCESS

To guide an SME toward the most relevant way to deploy its ACAP according to the context of its contribution to a CN, we formulated equations predicting the scores of the relevant ACAP dimensions and practices for the SME. PLS generates these equations by the means of two models, namely the inner and the outer models (Hair et al., 2011). The outer model measures the latent variables using their indicators; while the inner model calculates the scores of the dependent variables based on their structural links with the independent ones. We explain the prediction process for the KPA of acquisition in the network setting-up stage (ACQ1), which can be similarly applied to the other five KPAs.

The inner model predicts the score of the KPA ACQ1 based on an SME's characterization of its context within a CN (equation 1). This score corresponds to the sum of a residual constant, and the scores of the contextual variables impacting the KPA ACQ1 weighed with their associated path coefficients. The scores of the contextual factors are calculated as the scalar products of their items' vectors and their associated weights' vectors. The constant, the path coefficients, and the factors' weights result from the PLS algorithm, while the items' vectors of the factors are informed by the SME to describe its embedding context in the CN.

$$(1)\ \boldsymbol{ACQ1} = 0.304\ COOP + 0.406\ ROLE + 0.164\ EXT + 0.457$$

The outer model calculates ACQ1 as the scalar product of its items' vector (practices' vector) and their associated weights' vector (equation 2). These weights result from the PLS algorithm.

$$(2)\ \boldsymbol{ACQ1} = \{0.163 \quad 0.101 \quad 0.105 \quad 0.226 \quad 0.153 \quad 0.251\} \begin{Bmatrix} ACQ1.2 \\ ACQ1.4 \\ ACQ1.5 \\ ACQ1.7 \\ ACQ1.8 \\ ACQ1.11 \end{Bmatrix}$$

Therefore, the equality between the two previous equations calculating ACQ1 generates a new equation where the practices' vector of the KPA ACQ1 is the unknown variable (equation 3). This new equation can be solved using the pseudo-inverse of Moore-Penrose (Penrose, 1955), which allows for determining the scores of the six absorption practices associated with this KPA as follows:

$$(3)\begin{Bmatrix} ACQ1.2 \\ ACQ1.4 \\ ACQ1.5 \\ ACQ1.7 \\ ACQ1.8 \\ ACQ1.11 \end{Bmatrix} = \frac{0.304\ COOP + 0.406\ ROLE + 0.164\ EXT + 0.457}{0.163^2 + 0.101^2 + 0.105^2 + 0.226^2 + 0.153^2 + 0.251^2} \begin{Bmatrix} 0.163 \\ 0.101 \\ 0.105 \\ 0.226 \\ 0.153 \\ 0.251 \end{Bmatrix}$$

To determine the relevant practices of this KPA for the SME, we first standardize the practices' predicted scores on a scale of 1 to 6. Then, we retain the practices whose standardized scores are greater than 3. The accuracy of this average value was discussed and validated during the two focus groups.

4.3 MATURITY SCALE

A literature review of extant maturity models enabled understanding the criteria and scales to measure maturity, and accordingly define these elements for the ACAP of an SME to contribute to innovation in a CN. CMMI evaluates the processes' maturity through their operational mastery, while other studies consider maturity as a composite notion including the effective mastery of processes, as well as the attitude of individuals in the organization regarding these processes (Bahli & Di Tullio, 2013; Le Dain et al., 2008). As knowledge absorption practices do not correspond to institutionalized processes and additionally integrate a behavioral dimension (Razak et al., 2016), we propose to evaluate the maturity of the studied ACAP not only in terms of the SME's ability to operationally implement absorption practices 'Capable to do', but also its propensity toward these practices 'Willing to do'.

To assess an SME's maturity based on these criteria, a maturity level between 1 and 4 is assigned to each evaluated practice within a KPA following the SME's response to two questions related to the defined maturity criteria (Table 1). For the capability criterion, an SME is expert (level 4) if it perfectly applies the methods and uses the tools that are needed for the absorption practice. For the willingness criterion, an SME is a firm believer (level 4) if it perceives the interest of implementing the practice and is willing to perform it whenever it is necessary.

Table 1 - Scale assessing an SME's maturity for each practice included in the six KPAs

Capable to do			**Willing to do**	
For this project, are you to capable of performing the following practice?			*For this project, do you think it is relevant that you implement the following practice?*	
Yes, I am perfectly capable of performing it	**4**	**Expert**	Of course, it is even necessary	**4 Firm believer**
Yes, I am capable but need more formalization	**3**	**Capable**	Yes, I agree	**3 Culturally rooted**
I have some ideas but don't know how to proceed	**2**	**Some ideas**	I am not against, but I am not entirely convinced	**2 Potentially receptive**

I can't do it and have no idea about how it could be done	**1 Not capable**	No, I don't find it relevant	**1 Culturally resistant**

Source: Authors' own work

The deployment of this maturity scale generates an assessment report of the SME's ACAP. The SME representatives discuss with the moderator the reasons behind the firm's maturity gap for each KPA and its underlying practices, starting with the most important KPAs that were predicted considering the SME's embedding context. Improvement recommendations are then formulated according to the nature of the deficient maturity criterion. A lack of capability will essentially require training and support for the SME's project team to better deploy the absorption practice. A lack of willingness will mainly entail motivational and communication initiatives to improve the awareness of the SME's project team regarding the benefits of the absorption practice. In the critical case, the SME's project team is neither convinced of the interest nor capable of implementing the absorption practice. If a large number of the practices evaluated by the SME is deficient regarding capability and willingness, participating in the CN with such a team can be risky. Also, the necessary improvements will be substantial in terms of implementation cost and time. Thus, it seems wise, before taking improvement steps, to analyze the adequacy of these individuals to represent the SME within the CN, as well as the SME's role in the network. These maturity scale and assessment were approved following the two focus groups.

5 DISCUSSION AND CONCLUSION

This research proposes a grid-based maturity model for ACAP of technology SMEs to support their contribution to innovation in CNs. The model captures established good practices in a form that is accessible to both researchers and practitioners. It was designed according to a design science approach with an iterative novel process that combines insights from an extensive literature review, and multiple sources of empirical qualitative and quantitative data. Hence, this study contributes to both academic understanding and managerial practice as follows.

5.1 THEORETICAL IMPLICATIONS

First, the present research unveils the contingent nature of ACAP (Lane et al., 2006) for a technology SME contributing to innovation in a CN. This firm would deploy practices of knowledge acquisition, assimilation, and application in a diachronic manner throughout the network's setting-up and operational stages. On one hand, although some absorption practices seem to be transverse to a CN's lifecycle (Appendix 1), their implementation substantially differs according to the considered stage. For instance, the interviews and quantitative analysis underlined that the use of databases for new knowledge acquisition is highly significant in the development phase. Also, the involvement of the client for the interpretation of its specifications is more important in the upstream stage. On the other hand, the interviews and focus groups conducted for the model's development highlighted a significant number

of absorption practices focusing on managing the risks of knowledge internalization and combination that are specific to each of the two CN stages. Most of these practices were never introduced in the existing ACAP operationalizations due to the limited attention of literature dealing with ACAP measurement to collaborative innovation contexts. Among these practices, we emphasize the necessity for an SME to assess, in the setting-up phase, the risks of collaborating with competitors and to question, in the development stage, the other actors' propositions likely to alter its contribution's quality.

Second, we provide a refined view of the contextualized variations of ACAP in the case of SMEs participating to innovation within CNs. Indeed, the quantitative study conducted within the model's development phase enabled the elaboration of a predictive process that guides an SME toward the most relevant ACAP dimensions and practices according to its context in a CN. As such, we offer evidence that the deployment of each ACAP component depends on the scope of several factors namely the presence of external and internal triggers, the SME's central role within the CN, and the peculiarities of its partners. These results provide 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.

Third, this study complements the information processing perspective (Galbraith, 1974) of technology SMEs contributing to innovation in CNs. In fact, the exchanges conducted with technology SMEs and key opinion leaders in innovation management empirically demonstrated the relevance of CNs as a key strategy for SMEs to access complementary resources and knowledge necessary to reach an innovative outcome (Lee et al., 2010). Nevertheless, although more knowledge has a positive link with performance, firms need to organize themselves and establish rules that guide the behavior of employees regarding knowledge, thereby leading to improved business results. This is specifically important when firms are following a response strategy to deal with uncertain environments (Dobrzykowski et al., 2015) as companies require more "*information that has to be processed between decision-makers*" (Galbraith, 1974, p. 28). The examined technology SMEs are directly concerned by the necessity to establish such rules since they engage in CN alliances in order to align with the increased technical and technological uncertainty and evolution in their sectors and propose innovative solutions in a shorter lead time to face the competition of established large companies (Tojeiro-Rivero & Moreno, 2019). Hence, we demonstrate that the right deployment of ACAP can help these SMEs manage knowledge spillovers in CNs and anticipate potential misalignment issues stemming from the difference with the other actors in terms of strategic orientations and cognitive frames (Lubatkin et al., 2001).

5.2 MANAGERIAL IMPLICATIONS

We provide technology SMEs participating to innovation in CNs with guidance on how to harness ACAP in order to better engage in these networks. On one side, we unveil absorption practices that are significant regardless of an SME's embedding context in a CN. Therefore, we raise the

awareness of technology SMEs on these highly critical practices that all the partners should successfully perform in order to achieve their common innovation goal. Examples of these primary practices are the necessity to conceive a business model commonly approved by the CN's actors, to contract the relationships in the CN in order to establish a conducive collaborative climate for the member organizations, and to use IT means for better sharing and capitalization of knowledge in the CN.

On the other side, the maturity model designed in this study may help SMEs thoroughly determine what collaborations make sense for them and what role they can plan in CNs. By assessing its ACAP for collaborative innovation, an SME can be aware of the most appropriate potential partners that would help this firm better respond to its internal and external triggers for innovation and enable it to compensate for the missing primary aspects of its ACAP.

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APPENDICES

Appendix 1 – Items associated with the contextual factors and the ACAP dimensions

Construct type	Label	Definition	Indicators	Scales	Source
Latent variables describing the SME's context in the CN	*EXT*	External circumstances driving knowledge absorption by the SME	*EXT1*	Rapid evolution of the industry's technologies	Zahra & George (2002)
			*EXT2**	High regulation of the industry's policy	Glazer & Weiss (1993)
			EXT3	High frequency of innovation in the industry	Bower & Christensen (1995)
			EXT4	High competitiveness of the market in the industry	Cohen & Levinthal (1990)
	ROLE	Role's centrality of the SME in the CN	*ROLE1*	Strong involvement in exchanges with the market	Goduscheit (2014)
			ROLE2	Strong involvement in project management	
			ROLE3	Strong involvement in technical coordination	
	INT	Internal circumstances driving knowledge absorption by the SME	*INT1*	Achieve an innovation that you will own	Lichtenthaler (2010)
			INT2	Generate financial profit	
			INT3	Acquire learnings	Ahuja (2000)
			INT4	Extend the professional network	
			INT5	Re-orientate the firm's strategy	Zahra & George (2002)
	COG	Cognitive distance of the SME and the CN actors	*COG1*	Distant disciplines regarding the other CN actors	Nooteboom et al. (2007)
			*COG2**	Different structure and/or culture regarding the other CN actors	
	COOP	COOP among the SME and the CN actors	*COOP1*	Similar expertise and/or activities regarding the other CN actors	Lubatkin et al. (2001)
			COOP2	Similar commercial strategy regarding the other CN actors	
KPAs for the SME's participation in the CN's setting-up stage	*ACQ1*	The SME's acquisition of external to participate in the CN's setting-up	*ACQ1.1**	Investigate technological knowledge	Lichtenthaler (2009)
			ACQ1.2	Investigate supply chain knowledge	Chauvet (2014)
			*ACQ1.3**	Investigate market knowledge	Camison & Forès (2010)
			ACQ1.4	Investigate knowledge on innovation project management	Chauvet (2014)
			ACQ1.5	**Investigate knowledge on collaboration innovation**	Interviews
			*ACQ1.6**	Mobilize databases	Ter Wal et al. (2011)
			ACQ1.7	Solicit the CN actors	Szulanski (1996)
			ACQ1.8	Solicit experts outside the CN	Flatten et al. (2011)
			*ACQ1.9**	Solicit the client	Jansen et al. (2005)
			*ACQ1.10**	Participate in industrial/scientific events	Camison & Forès (2010)
			ACQ1.11	Be inclined to investigate any other useful knowledge area	Camison & Forès (2010)
	ASS1	The SME's assimilation of external to participate in the CN's setting-up	*ASS1.1*	Involve the client	Jansen et al. (2005)
			ASS1.2	Ensure a coherent vision by exchanging with the CN actors	Ter Wal et al. (2011)
			ASS1.3	Exchange with the CN actors and the client using boundary objects	Flatten et al. (2011)
			ASS1.4	**Evaluate the pros and cons to take part in a network with unusual actors**	Interviews
			ASS1.5	**Be inclined to integrate a network with unusual actors**	Interviews
	APP1	The SME's application of external to participate in the CN's setting-up	***APP1.1***	**Explain your participation in the budget**	Interviews
			APP1.2	**Explain your intended operational contribution**	Interviews
			*APP1.3**	Designate individuals from your firm for this project	Jansen et al. (2005)
			APP1.4	Recognize your future interfacing actors in the CN	Szulanski (1996)

			APP1.5*	**Set-up project management procedure**	Interviews
			APP1.6	**Set-up features for monitoring the innovation performance**	Interviews
			APP1.7*	**Implement the tools for effective collaboration and interface steering**	Interviews
			APP1.8	**Explain your terms of collaboration**	Interviews
			APP1.9	**Define a commonly agreed business model with the CN actors**	Interviews
			*APP1.10**	Designate boundary spanners for the CN	Jimenez-Barrionuevo et al. (2011)
			APP1.11	**Agree on the legitimacy of the boundary spanners**	Interviews
			APP1.12	**Sign formal contracts with the other actors**	Interviews
			APP1.13*	**Evaluate the consistency of the project with your strategic orientation**	Interviews
			APP1.14	**Be inclined to adjust your own goals for the network benefit.**	Interviews
KPAs for the SME's participation in the CN's development stage	*ACQ2*	The SME's acquisition of external to participate in the CN's operation	***ACQ2.1***	**Recognize the requirements/constraints of the input actors of your contribution**	Interviews
			ACQ2.2	**Recognize the requirements/constraints of the output actors of your contribution**	Interviews
			ACQ2.3	Solicit the CN actors	Chauvet (2014)
			*ACQ2.4**	Solicit experts outside the CN	Tu et al. (2006)
			*ACQ2.5**	Solicit the client	Jansen et al. (2005)
			ACQ2.6	Mobilize databases	Ter Wal et al. (2011)
			*ACQ2.7**	Participate in industrial/scientific events	Camison & Forès (2010)
			ACQ2.8	Be inclined to investigate any other useful knowledge area	Flatten et al. (2011)
	ASS2	The SME's assimilation of external to participate in the CN's operation	*ASS2.1**	Involve the client	Jansen et al. (2005)
			ASS2.2	**Exchange with your interfacing actors**	Interviews
			*ASS2.3**	Ensure a coherent vision by exchanging with the CN actors	Ter Wal et al. (2011)
			ASS2.4	Exchange with the CN actors and the client using boundary objects	Flatten et al. (2011)
			ASS2.5	Use IT means to share knowledge with the other actors and the client	Camison & Forès (2010)
			ASS2.6*	**Question the suggestions of the other actors and the client**	Interviews
			ASS2.7	**Be attentive during the network exchanges to leakages of your key knowledge**	Interviews
			ASS2.8	Be inclined to integrate uses other than your ways of doing	Tu et al. (2006)
	APP2	The SME's application of external to participate in the CN's operation	*APP2.1*	Work jointly with your interfacing actors	Valentim et al. (2015)
			APP2.2	**Test the innovation with the client**	Interviews
			APP2.3*	**Promote the innovation in events**	Interviews
			APP2.4	**Rely on appropriate advanced technological means to achieve your contribution**	Interviews
			APP2.5	Document your contribution	Jimenez-Barrionuevo et al. (2011)
			APP2.6	Challenge your contribution's performance	Nieto & Quevedo (2005)
			APP2.7	**Raise your doubts during the innovation development and commercialization**	Interviews
			APP2.8*	**Allocate further resources to the project id required**	Interviews
			APP2.9	Assist the other CN actors to achieve their contributions	Tu et al. (2006)
			APP2.10	**Be inclined to adjust your accomplished contributions based on the project needs**	Interviews

**Indicator resulting from the interviews*

Indicator omitted during the quantitative analysis