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Absorptive capacity development in some firms in Brazil: an organizational perspective [*]

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Abstract

This article analyzes how some firms that interacted with universities in Brazil combine different organizational processes and characteristics to develop their Absorptive Capacities (ACAPs). For that, the techniques of Categorical Principal Component Analysis (CatPCA) and Qualitative Comparative Analysis (QCA) are used to analyze data from a survey specific to this objective. The findings reveal that distinct ACAPs, linked with diverse strategies, require specific "organizational configurations" for their development. If ACAPs are developed to expand the knowledge base, without a specific application, they depend on the combination of strong personal relationships within and outside the firm. When ACAPs are geared towards adapting existing technologies, these interpersonal relationships must synergize with managerial practices that involve employee engagement in strategic innovative projects. Finally, if ACAPs are developed to achieve results with a specific appropriability, these internal practices and relationships are combined with a high internal hierarchy that guides the process.

Keywords: Organizational dimension; Absorptive capacity; Qualitative Comparative Analysis*;* Categorical Principal Component Analysis (CatPCA); University-firm relationship.

Resumo

Desenvolvimento da capacidade de absorção em algumas empresas no Brasil: uma perspectiva organizacional

O presente artigo analisa como algumas empresas que interagiram com universidades no Brasil combinam diferentes processos e características organizacionais para desenvolver suas Capacidades Absortivas (CAs). Para isso, combinam-se as técnicas de Análise de Componentes Principais Categóricos (CatPCA) e *Qualitative Comparative Analysis* (QCA) para analisar dados de um *survey* específico ao objetivo. Os resultados indicam que diferentes Capacidades Absortivas (CAs), vinculadas a estratégias distintas, requerem configurações organizacionais específicas, como arranjos internos e externos, para serem desenvolvidas. CAs voltadas à ampliação da base de conhecimento, sem uma aplicação específica, dependem da combinação entre fortes relações pessoais intraempresa e externas a ela. Quando as CAs são voltadas para adaptar tecnologias existentes, essas relações pessoais devem ser complementadas por práticas gerenciais que incentivem ativamente a participação dos trabalhadores em projetos estratégicos de inovação. Por fim, se as CAs são construídas para alcançar resultados com apropriabilidade mais específica, essas práticas e relações internas são combinadas com uma elevada hierarquia interna que direciona o processo.

Palavras-chave: Dimensão organizacional; Capacidade de absorção; *Qualitative Comparative Analysis* (QCA); Análise de Componentes Principais Categóricos (CatPCA); Interação universidade-empresa
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1 Introduction

Firms do not innovate in isolation. Inserted in an Innovation System, they innovate by accessing knowledge networks and interacting with other agents, such as suppliers, competitors, and universities (Lundvall et al., 2009). To do this, firms need to build and manage internal capabilities to identify the relevant knowledge, assimilate it, and effectively apply it commercially. In other words, they need to develop Absorptive Capacities (Cohen; Levinthal, 1989, 1990).

Considered an organizational capability (Cohen; Levinthal, 1990; Nelson; Winter, 2005), the development of the Absorptive Capacity (ACAP) does not depend only on internal efforts in Research and Development (R&D), as it is usually associated, but also "on the links across a mosaic of individual capabilities" (Cohen; Levinthal, 1990, p.133). This connection relies on organizational structures, processes, and practices, such as promoting worker participation in innovative projects and implementing formal internal procedures, etc. (Jansen; Bosch, Van Den; Volberda, 2005). These organizational elements can be read as "practical routines" (Lewin; Massini; Peeters, 2011) that help to transform dispersed individual abilities into organization-level capabilities (Milagres, 2011; Nelson; Winter, 2005).

This paper focuses on this organizational dimension of ACAP, analyzing how some firms that interacted with universities in Brazil combine different organizational processes and characteristics in favor of their Absorptive Capacities. For this, the techniques of Categorical Principal Component Analysis (CatPCA) and fuzzy-set Qualitative Comparative Analysis (fsQCA) are combined to analyze data from a specific survey to measure the organizational dimensions and determinants of ACAP of these firms. This survey was conducted between 2015-2016 with firms that had previously interacted with universities.

Some contributions to literature are made. First, this paper advances in measuring the multidimensionality of ACAP and understanding its organizational aspects, as suggested by some authors (Paranhos; Hasenclever, 2021; Volberda; Foss; Lyles, 2010), but in a developing country context. Second, the fsQCA identifies multiple pathways to achieve the same level of ACAP, highlighting the evolutionary nature of capability development (Nelson; Winter, 2005), which is often overlooked in traditional econometric studies. Third, the results reinforce the relevance of labor abilities in the Brazilian university-firm context (Negri, 2006; Teixeira; Rapini; Caliari, 2020), especially when firms focus on developing an ACAP to adapt existing technologies.

The paper is structured across four more sections. The second section debates the concepts, interpretations, and select organizational determinants of ACAP. In the third section, methodologies are discussed, encompassing the presentation of the database and the techniques employed. The fourth section analyzes the results. Lastly, the concluding section houses the final remarks.

2 Absorptive capacity: interpretations and relevance of the organizational dimension

2.1 Different conceptual interpretations of ACAP

The concept of ACAP was defined by Cohen and Levinthal (1989, 1990) as a firm's ability to identify relevant external knowledge, assimilate it, and apply it commercially. Initially,

this ability was seen as a by-product of internal R&D efforts. However, in a later study, Cohen and Levinthal (1990) employed Nelson and Winter's (2005) concept of organizational capability to elaborate on the intra-firm elements that support the development of ACAP. Among these elements are the gatekeepers, interfaces between the firm's areas and external agents, and actions that favor the dissemination of intra-firm knowledge. These actions allow for connecting a mosaic of individual abilities (Cohen; Levinthal, 1990) in favor of building a capability at the organizational level. After this initial work, different reinterpretations have been carried out, and three of these can be highlighted.

Zahra and George (2002) redefine the ACAP as a dynamic capability composed of potential and realized capabilities. Potential ACAP is composed of acquisition and assimilation capabilities. The first is related to the firms' capabilities to recognize the value of new external knowledge, acquire it, and add it to their knowledge base, while the second is related to the routines and processes that allow the company to analyze, process, and interpret external knowledge, given the existing knowledge. The second set – realized ACAP – reflects the capabilities for transforming and exploiting external knowledge, where the former refers to the processes for combining old knowledge with new knowledge, and the latter is associated with the ability to apply knowledge commercially, aiming at raising or building competencies. For the authors, the higher the ratio between realized ACAP and potential ACAP, the greater the efficiency in absorption, that is, in applying the assimilated knowledge in innovations and competitive advantages. This "efficiency factor" would be determined by "social integration mechanisms" (Zahra; George, 2002) to be discussed in the next subsection.

Criticizing the "static" characteristic of this "efficiency factor", Lane, Koka, and Pathak (2006) redefine ACAP as a sequential process composed of three forms of learning: exploratory, transformative, and exploitative learning. The first learning allows the company to recognize and understand the potential of external knowledge, which is related to the first dimension of ACAP proposed by Cohen and Levinthal (1990). Transformative learning, on the other hand, refers to processes for assimilating external knowledge and combining it with existing knowledge, encompassing the assimilation and transformation capabilities exposed by Zahra and George (2002). It is responsible for making a connection between exploratory and exploitative learning. The latter, in turn, is related to the application of this new external knowledge. Using March (1991) and Bishop D'Este and Neely (2011), it can be said that exploratory learning contributes especially to obtaining long-term benefits by expanding and diversifying the internal knowledge base, giving greater flexibility to the company; whereas exploitative learning is more focused on the application of knowledge in products and processes, focusing on short-term results and more direct appropriability.

Lane, Koka and Pathak (2006) also contribute to the literature by decomposing ACAP into two parts: (1) funnel; (2) pipelines. The first would allow the company to select which are the relevant knowledge for its strategies, approaching Cohen and Levinthal's (1990) "recognition" dimension. This funnel would be determined by the breadth of the company's previous knowledge base, built especially through exploratory learning. The pipelines, on the other hand, refer to intra-company organizational processes that favor transformative and

exploitative learning, allowing the internalization of external knowledge considered relevant and its application in the market.

Lewin, Massini, and Peeters (2011) share this "bipartite" view of ACAP. For the authors, the ACAP would be formed by a connected set of internal and external meta-routines expressed in observable practical routines. Internal meta-routines are associated with the process of intrafirm knowledge construction, refinements, and sharing, helping to build an intrafirm knowledge base; they are routines that help to (1) modify old routines, (2) emerge and select new intrafirm ideas, and (3) share existing knowledge and practices. The external meta-routines are more directly aimed at the search for external knowledge, being linked to the practical routines for recognizing the value of external knowledge and learning from external partners, such as the use of gatekeepers, participation in networks, and R&D partnerships. These routines are focused on identifying and acquiring external knowledge, aligning with the funnel concept of ACAP. According to the authors, the effectiveness of the ACAP depends on the connection between these two meta-routines, which would be accomplished by meta-routines focused on (1) creating stimuli to explore knowledge and opportunities (internal or external) and (2) transferring the external knowledge inside the company through specific processes, such as the sharing of external knowledge among gatekeepers and other employees. Without these processes, the effectiveness of external ACAP diminishes, making absorption highly reliant on the individual capabilities of gatekeepers (Lewin; Massini; Peeters, 2011). This point will be important in the empirical analyses, as well as Lane, Koka and Pathak's (2006) interpretation of ACAP.

2.2 Some organizational determinants of ACAP

As highlighted, the ACAP is an organizational capability that also depends on processes and routines that disseminate knowledge internally and connect and drive the actions of individuals (Zahra; George, 2002). Some of these processes are highlighted below, focusing on those measured in the empirical analysis. An extensive review of them is made by Volberda, Foss and Lyles (2010).

First, Cohen and Levinthal (1990) already highlighted theoretically the importance of **actions to disseminate intra-firm knowledge**. These actions act as "social integration mechanisms", facilitating the flow of intra-firm knowledge and the transformation and exploitation of external knowledge (Zahra; George, 2002). Examples of these actions include the promotion of informal interactions among employees, open communication of ideas, mutual support among departments, and the conducting of internal seminars (Schmidt, 2005).

Another important action in favor of ACAP is the **participation of employees in innovative projects**. Jansen, Van den Bosch, and Volberda (2005) interpret this participation as greater freedom in the agents' decision-making, but it has a dubious effect. On one hand, it increases the ability and motivation of workers to acquire and assimilate external knowledge, but, on the other hand, it hinders consensus building, which would negatively affect the realized ACAP. However, Ebers and Maurer (2014) claim that this greater participation would have a positive effect on the realized ACAP by allowing greater collaboration and intra-company knowledge exchange.

Formalizations and routines also have dubious effects on ACAP. For Van den Bosch, Volberda and De Boer (1999), these formalizations allow the knowledge exchange to occur through formal means, such as information systems or procedures exposed in documents, manuals, etc. However, these have dubious effects on both potential and realized ACAP. For the potential ACAP, these formalizations could increase the efficiency in the acquisition of external knowledge (Vega-Jurado; Gutiérrez-Gracia; Fernández-De-Lucio, 2008) or restrict the integration among the members of the company, which disfavors the potential ACAP (Jansen; Van Den Bosch; Volberda, 2005). For the realized ACAP, formalizations help codify the best practices for the application of external knowledge, but, on the other hand, reduce the creativity and flexibility important for this dimension (Jansen; Van Den Bosch; Volberda, 2005; Vega-Jurado; Gutiérrez-Gracia; Fernández-De-Lucio, 2008).

The determinants discussed above involve more managerial and deliberate decisions. However, for Ebers and Maurer (2014), ACAP can also be favored by **strong and trusting personal relationships**. For the authors, this kind of internal relationship contributes to communication and knowledge exchange among employees, favoring the transformation and commercial exploitation of new knowledge. Strong and trusting relationships between the company's employees and external partners, on the other hand, affect potential ACAP by favoring the identification and assimilation of external knowledge.

Finally, the development of capabilities cannot be separated from the company's structure (Nelson, 1991). Van den Bosch, Volberda and De Boer (1999) analyze three types of structural forms (functional, divisional, or matrix), identifying that more hierarchical forms – such as the functional – tend to contribute to the efficiency of the external knowledge absorption, but not to its scope or flexibility. On the other hand, less hierarchical forms – such as the divisional – favor the flexibility of this ACAP, but limit it as a whole due to the low integration between the departments that characterize them. Thus, the ACAP tends to be favored by an intermediate **degree of hierarchy**, in which there are gatekeeper positions and stronger connections between R&D and manufacturing departments, but with some departmental autonomy around diverse projects. This favors the efficiency, scope, and also flexibility of ACAP (Van Den Bosch; Volberda; De Boer, 1999; Duchek, 2015).

The next sections empirically investigate the effect of the mentioned organizational determinants on the ACAP of firms that interacted with universities. These firms tend to have distinctive capabilities compared to those that do not do this, because, on the one hand, this interaction is a way to develop ACAP by the improve of the knowledge base (Bishop; D'este; Neely, 2011) and, on the other hand, it requires peculiar prior ACAP, built by distinct organizational processes and innovative efforts (Lane; Lubatkin, 1998; Murove; Prodan, 2009; Negri, 2006; Schmidt, 2005). However, in a Brazilian context, the development of ACAP can be limited because the firms' short-term strategies that use the universities not only as complementary but also as substitutes for their internal R&D activities (Rapini et al., 2009; Teixeira; Rapini; Caliari, 2020).

3 Methodological elements

3.1 Database

The present study uses a database developed between 2015-2016 specifically to measure the ACAP dimensions and their organizational determinants, focusing on firms that had interacted with universities in Brazil, according to the 2010 census of Research Groups Directory of the Brazilian National Council for Scientific and Technological Development (DGP/CNPq, in Portuguese). It is also collected information about the innovative activities of firms and their interaction with universities. As discussed before, these firms have different ACAP, but it is not possible to say a bigger or better ACAP them others, necessarily. A diversity of ACAP will be identified during section 4.

A detailed description of this base is provided by Teixeira (2020). Here, we focus on presenting its basic characteristics and the analyzed variables. Tables 1, 2, and 3 show the variables and references used for their construction. The questionnaire was applied in Portuguese, but the questions are translated here.

As shown in these tables, the analyzed variables were measured on a Likert scale with 4 levels of importance, plus a fifth level called "unable to give an opinion" (or to respond). It is argued that responses to this item indicate (i) a lack of understanding of the respondent about the question or (ii) a lack of knowledge about a particular action.

Regardless of the interpretation, it is assumed that if the respondent chose this option in all items referring to at least one "construct" (i.e., a dimension or a determinant of the ACAP), the answer does not portray the construct in question and, therefore, such a company is removed from the sample. On the other hand, if at least one item of the construct is answered in another way, then this company is kept in the sample, understanding that it provides some minimal information for it. With this strategy, it was possible to maintain a greater number of firms, but, a different treatment was necessary via the Categorical Principal Components Analysis (CatPCA), discussed in section 3.2.

It is important to highlight that specific ACAP surveys are important to capture ACAP multidimensionality and its dependence on organizational factors that go beyond R&D efforts (Ebers; Maurer, 2014; Jansen; Bosch, Van Den; Volberda, 2005). However, there is no consensus on how to measure absorptive capacity, given that different studies focus only on the ACAP dimensions and do not measure their organizational determinants in the same questionnaire (Camisón; Forés, 2010; Flatten et al., 2011; Jiménez-Barrionuevo; García-Morales; Molina, 2011). This makes it difficult to separate the antecedents of the ACAP and the "core" of its dimensions – a criticism similar to the use of R&D as a proxy for the ACAP (Flatten et al., 2011) –, in some cases requiring the use of the original concept to measure a given dimension.

Table 1
Questions about the dimensions of ACAP

Dimension	Code	Question	Ref.
Introductory question: Evaluate the company's ability to identify and acquire relevant external information and knowledge for its innovative activities. Consider the following to answer: [*]			
Acquisition capabilities (Ac)	Ac_search_const	The search for relevant information about our sector is constant in the day-to-day business of our company	R; F
	Ac_ident_ot_Univ_RI	We easily identify technological opportunities at Universities or Research Institutes	Own
	Ac_ident_ot_market	We easily identify the technological opportunities that arise in the market	Own
	Ac_similar_know	Our knowledge is similar to the knowledge generated by the external supplier, facilitating the identification and acquisition of external knowledge	Own; L
Introductory question: Evaluate the company's ability to interpret and assimilate external knowledge obtained. Consider the following to answer: [*]			
Assimilation Capabilities (As)	As_resour_complem	The resources and capacities of the company and the external organization providing information and knowledge are complementary, facilitating the assimilation of new knowledge	Ji; R
	As_worker_interpret	Our workers can interpret external knowledge in a way that satisfies the company's objectives	Own
	As_market_change	We quickly interpret, process, and understand market changes that are important to our company	Ja
	As_new_know_Univ_RI	We quickly interpret, understand, and process the new knowledge generated by Universities and/or Research Institutes	Ja
	As_no_change_ know_base	To process and assimilate the new external knowledge, it was not necessary to substantially change the existing knowledge structure in the company.	Own; T
Introductory question: Evaluate the company's ability to combine new knowledge with existing knowledge. Consider the following to answer: [*]			
Transformation Capabilities (T)	T_adapt_tec	We can adapt technologies developed by others to the particular needs of the company	C; R
	T_worker_link_know	Our workers link the new knowledge obtained externally and the knowledge already existing in the company	R; F
	T_change_know_base	The processing of new external knowledge required a reconfiguration of the company's existing knowledge structure	Own; T
	T_worker_use_know_pract	Our workers can apply new knowledge to their work practices	R; F
Introductory question: Evaluate the company's ability to commercially exploit the new knowledge and/or apply it to new products, processes etc. Consider the following to answer: [*]			
Exploitation Capabilities (E)	E_const_search_aplly_know	We constantly consider how to better exploit external knowledge to generate innovation	Ja
	E_cap_use_new_ know_changes	We have capabilities that allow us to use and exploit new knowledge, in order to respond quickly to changes in the environment, and gain a competitive advantage	C; R
	E_apply_new_know_innov	We can apply new knowledge to new products and processes	C; R
	E_improve_ compet_market	The new external knowledge was essential for the company to leverage its competencies, increase its participation in the market, or reach new markets.	Own
	E_work_more_effective	Our company can work more effectively through the adoption of new technologies and knowledge	R; F

Source: Own elaboration. All questions were done in Portuguese and answered according to the following scale: (1) Strongly disagree; (2) Partially disagree; (3) I partially agree; (4) Strongly Agree; (5) Unable to give an opinion. This scale is represented by the symbol [*] in the introductory questions' lines. Notes: "Ref." is "references"; "C" is Camisón and Fóres (2010); "F" is Flatten et al., (2011); "Ja" is Jansen, Van den Bosch and Volberda (2005); "Ji" is Jiménez-Barrionuevo, García-Morales and Molina (2011); "L" is Lane and Lubatkin (1998); "Own" is "Own Elaboration"; "R" is Rosa (2013); "T" is Todorova and Durisin (2007).

Table 2
Questions to measure the organizational determinants of ACAP (a)

Determinant	Code	Question	Ref.
Introductory Question: About your company, evaluate the extent to which you agree or disagree with the following questions. Consider the following to answer [*]			
Degree of internal hierarchy (h)	h_worker_restricted_tasks	Employees perform a restricted range of tasks, featuring a strong division of labor	Van
	h_dep_no_freedom	The hierarchy is very extensive from the bottom to the top, with little freedom for each departmental level to make decisions	Van
	h_high_drive_action	High levels of the hierarchy drive the decisions and actions of the departments	Van
Strength and trust in the internal relationship (tsi)	tsi_freq_communic	People responsible for innovation and other colleagues in the company communicated very often with each other	E
	tsi_proffesional_ compet_action	People responsible for innovation and other colleagues in the company could always trust that each other would decide and act professionally and competently	E
	tsi_receive_info	People responsible for innovation and other colleagues in the company could always trust that each would receive necessary and reliable information and service	E
	tsi_keep_promises	People responsible for innovation and other colleagues in the company could always trust that each would keep the promises	E
Introductory question: The questions below refer to actions to promote employee participation in innovative projects. Consider the following to answer: [*]			
Employee participation in innovative projects (workProj)	workProj_high_influen	Employees have a high degree of influence over the actions of the innovative projects of the company	E
	workProj_implement_decision	Employees are allowed to implement many decisions in the process of generating innovation	E
	workProj_tec_ raise_part	The techniques of Quality Circles, Methods of Analysis and Solve Problems (Ex .: MASP, fishbone, 5W2H, cause-effect diagram) were important to promote the participation of employees in the company's innovative projects	Ve
	workProj_idea_bank	The "Bank of Ideas" was important to bring employees closer to the company's innovative projects	Own
	workProj_reward_idea	Employees are rewarded for implementing suggestions and ideas	Own
Introductory question: Evaluate the importance of Formalization and Routines to identify, understand, and use external knowledge to innovate. Consider the following to answer: [*]			
Formalization and Routines to absorb external knowledge (r)	r_training	Training focused on innovation is constant in our company	E;Ve
	r_formal_proc_search_assimi	Our company has formalized processes in documents (physical or electronic) that help in the search, acquisition, and understanding of external knowledge	Ja
	r_rules_doc_use_know	Our company has explicit rules on documents (physical or electronic) that help in using this knowledge to generate innovation	Ja
	r_encourage_proto	The manager encourages the development of prototypes	F
Introductory question: Regarding the strength and trust in the relationship between our company and other organizations that provide knowledge (Universities, Technological Centres, Consultancies, Research Institutes, etc.), consider the following to answer: [*]			
Strength and trust in external relations (tse)	tse_interac	There is interaction between the people of the two organizations	E
	tse_high_reciprocity	The relationship between our company and the external organization is characterized by a high degree of reciprocity	E
	tse_freq_communic	Communication is frequent between our company and the external organization	E
	tse_mutual_trust	The relationship between our company and external organizations is characterized by mutual respect and trust	E

Source: Own elaboration. All questions were done in Portuguese and answered on the following scale: (1) Strongly disagree; (2) Partially disagree; (3) I partially agree; (4) Strongly Agree; (5) Unable to give an opinion. This scale is represented by [*]. Notes: "Ref" is "References"; "Own" is own elaboration; "E" is short for "Ebers and Maurer (2014); "F" is Flatten et al., (2011) "; "Ja" is Jansen, Van den Bosch and Volberda (2005); "Van" is Van den Bosch, Volberda and De Boer (1999); "Ve" is "Vega-Jurado, Gutiérrez-Gracia and Fernández-de-Lucio (2008).

Table 3
Questions to measure the organizational determinants of ACAP (b)

Determinant	Code	Question Description	Ref
Introductory question: Evaluate the degree of importance of the actions listed below to disseminate external knowledge in your company. Consider the following to answer: (1) No important (2) weakly important (3) moderately important (4) highly important (5) Unable to answer			
Actions to disseminate external knowledge internally (diss_)	diss_informal_contact	Informal contact among employees	S
	diss_develop_innov_strategy	Development of innovation strategies	S
	diss_mutual_support	Mutual support of other areas of the company with innovation-related problems.	S
	diss_regular_meet_managers	Regular meetings between managers from several areas of the company to discuss topics related to innovation	S
	diss_workshop	Seminars and workshops for innovation projects involving several areas of the company	S
	diss_job_rotation	The exchange of personnel between departments or functions occurs regularly (eg. the use of the techniques of job rotation)	Ja; Ve

Source: Own elaboration: "Ref" is "References"; Notes: "S" is equivalent to Schmidt (2005); "Ja" is Jansen, Van den Bosch and Volberda (2005); "Ve" is short for "Vega-Jurado, Gutiérrez-Gracia and Fernández-de-Lucio (2008).

Regarding the general features of the database, it is worth noting that the collection process resulted in 57 responses[1]. After the process of cleaning, it has resulted in 39 valid responses[2], whose characteristics are described in Table 4. The firms are of different sizes, sectors, and regions. There is a predominance of national firms that interacted with universities in the three years before the survey (until 2015 or 2016, depending on when the company answered it)[3]. Regarding the respondents, more than half of them have been in the company for at least 6 years (66.7%), have a post-graduation, specialization, or MBA (61.5%), and are linked to management or R&D activities and innovation (53.8%). Such characteristics suggest, in general, a respondent with the ability to understand the questionnaire and with reasonable knowledge about the organizational characteristics and processes of the company.

Therefore, some characteristics of the database demand alternative methods of analysis: (1) a small number of valid responses; (2) responses such as "unable to express an opinion" are classified as missing; (3) non-linear Likert-type responses; (4) possible non-linear relationships between variables. To meet these specificities, the Categorical Principal Component Analysis (CatPCA) techniques will be combined with fuzzy-set Qualitative Comparative Analysis (fsQCA), where the first builds "super conditions" (Berg-Schlosser; De Meur, 2009) to be used

(1) Some information about this process is important. First, we identify a phone contact of the firm and the target respondent (e.g. responsible for the R&D/Innovation department, interactions or product development), followed by the send of the questionnaire by email. The questionnaire was applied by SurveyMonkey® homepage. After this, phone contacts to explain the survey and request the answer was done frequently by graduating or post-graduating students. These contacts, in general, followed a guide developed for this and presented in Teixeira et al., (2017).

(2) Three types of exclusions were carried out: (a) firms that had not answered all questions about the ACAP dimensions; (b) more than one answer for the same company; (c) firms that have marked "Unable to give an opinion" for all questions relating to at least one of the dimensions or one of the organizational determinants of ACAP described in Tables 1 to 3.

(3) The database is not representative of the universe of firms that interact with universities in Brazil. According to the 2010 DGP/CNPq Census (our starting point), 2,543 firms had interactions with research groups. Initially, a representative sample (in sector and region aspects) of 600 firms was designed. However, because of time, money, and labor limitations, it was not possible to achieve it. Besides this limitation, we consider that the database has important information about the organizational dimension of ACAP and their exploration could encourage new and larger studies about the theme. More database information is explained in Teixeira (2020).

in the second to explain the desired outcomes (i.e. the high ACAP). These techniques are detailed below.

Table 4
Description of the basic characteristics of the firms analyzed (Total: 39 firms)

Firm Size (in terms of employees)	Number	%
Micro (equal or less than 19)	7	17.9
Small (20 to 99)	8	20.5
Medium (100 to 499)	7	17.9
Big (equal or more than 500)	14	35.9
Without answer	3	7.7
Region	Number	%
North	1	2.6
Northeast	15	38.5
Southeast	9	23.1
South	8	20.5
Midwest	6	15.4
Origin of controlling capital	Number	%
National (Brazilian)	29	74.4
International	5	12.8
Mix between then	5	12.8
Sector (CNAE-code)	Number	%
Agriculture, livestock, and related services/(01)	4	10.3
Manufacture of food products (10), beverages (11) or leather goods, travel goods and footwear (15)	3	7.7
Manufacture of chemical (20) or non-metallic mineral products (23)	2	5.1
Manufacture of machinery and equipment (28)	4	10.3
Manufacture of motor vehicles, trailers and bodywork (29)	2	5.1
Electricity, gas, and other utilities (35)	13	33.3
Activities of information technology services (62)	3	7.7
Information service activities (63)	1	2.6
Other professional, scientific, and technical activities (74)	1	2.6
Other services (45, 46, 64, 70 or 77)	6	15,4
Have firms interacted with universities or research institutes in the past three years?	Number	%
No	5	12.8
Yes	34	87.2

Source: Own elaboration. Note: CNAE-code is the Brazilian official code to classify sectors and it is similar to the International Standard Industrial Classification (ISIC).

3.2 Categorical Principal Component Analysis (CatPCA)

The CatPCA is analogous to the linear Principal Component Analysis (PCA) but with a non-linear feature. The CatPCA reduces many variables into a smaller set of uncorrelated principal components, minimizing the loss of information. The method consists of considering each observed value of the ordinal categorical variable as a "category". Each category is converted into a numerical value through a non-linear function (via the optimal scaling quantification method), transforming the categorical variables into quantifiable variables (Linting et al., 2007). In the present study, there are four "valid" categories: 1, 2, 3, and 4. This method quantifies each category, allowing, for example, that the difference between category 1 (strongly disagree) and category 2 (partially disagree) is less than the difference between this second category and category 3 (partially agree). As a result, the ordinal character of Likert-scale responses is

considered in the analysis more appropriately than in traditional techniques such as linear Principal Components and Factor Analysis (Linting et al., 2007). Besides accounting for the ordinal nature of the variables, this method has other advantages, such as: (a) suitability for datasets with few observations or more variables than observations; (b) no requirement for multivariate normality; and (c) internal handling of "unable to give an opinion" responses, ensuring more comprehensive data use (Linting et al., 2007; Meulman; Heiser, 2011; Meulman; Kooij; Van Der; Heiser, 2004).

Specifically, about point c, the CatPCA allows treating responses of the type “not able to give an opinion” in two ways: passive and active. In both cases, this response is treated as missing, however, its contribution is different for the quantification of the categories and the construction of the principal components. In passive form, for example, if a company answers a question – for example, question “Ac_search_const”- as “not able to give an opinion “, but answers all the others questions as 1, 2, 3, or 4, that company is not considered for the transformation of the variable “Ac_search_const”, but it is considered for all other variables. Besides, the object scores (i.e. the value of indicators) do not take into account the variable “Ac_search_const” to calculate it. The active form treats missing values as an additional category and includes them in all stages of the quantification process (IBM, 2011; Meulman; Kooij; Van Der; Heiser, 2004). In the present study, the passive form was chosen[4].

However, this way of dealing with missing values has consequences. First, the object scores do not necessarily have a weighted average of zero. Second, the CatPCA does not maximize the P values of the correlation matrix between the transformed variables, but of a similar matrix, which differs especially by incorporating a diagonal matrix Mj that considers two possible values: (i) equal to zero if the object (i.e. the company) is missing in variable j and the passive strategy was adopted; (ii) equal to the weight of the variable, otherwise. As a result, component loadings do not necessarily vary between -1 and 1 and cannot be directly interpreted as the correlation between the transformed variables and the principal component in question. However, a high component loading, in the mathematical module, continues to represent a high importance of a certain variable in the composition of a given component. The direction of this relationship also continues to be represented by the sign of this component loading (IBM, 2011; Meulman; Kooij, Van Der; Heiser, 2004). Therefore, in the analysis of the results of the CatPCA (section 4.1) the term “importance of a given variable” will be used instead of the term “correlation” to interpret the values of the component loadings. A mathematical detail of this method can be found in IBM (2011).

3.3 Qualitative Comparative Analysis (QCA)

The indicators built via CatpCA are used as conditions or outcomes in QCA. The last technique is relevant to this study because (i) it identifies different behavioral patterns leading to the same result and (ii) is suited for studies with few cases, typically fewer than 100, but with many explanatory variables (Berg-Schlosser et al., 2009). Both are characteristics of the present study.

(4) If the active form had been chosen, the CatPCA would estimate a value for the category “not able to give an opinion”. However, given the small size of the sample, the number of this kind of answer is low to justify and support this estimation. In other words, a parsimonious perspective guided the choice.

Regarding point (*i)*, it is not necessary to recognize a single specific causal model that best fits the data, allowing the identification of different combinations and configurations that lead to the same result, the so-called conjunctural causality (Berg-Schlosser et al., 2009). Regarding this, consider that variables A, B, C, D, and E may be possible conditions to generate the same product Y (e.g. high ACAP level). Then, the application of the QCA may conclude that the configuration of factors AB or ACD generates Y (AB or ACD → Y). Or, still, the lower value of a factor may be important to achieve the same result: aC → Y, where [a] is the designation for lower values of factor [A]. In theoretical terms, this is relevant because it allows different firms to combine differently the organizational processes analyzed and achieve similar levels of absorptive capacity. Furthermore, this is in line with the vision of ACAP as an organizational capability (Cohen; Levinthal, 1990), dependent on intra-firm routines (Lewin; Massini; Peeters, 2011) that can be used differently between firms (Nelson, 1991; Nelson; Winter, 2005). This heterogeneity is difficult to capture in econometric models or linear analyses (Berg-Schlosser et al., 2009), being less present in the literature.

In this work, the fuzzy-set QCA method (fsQCA) is used, which allows the score of association to a group within the range between 0 and 1. Values greater than 0.5 indicate that the company belongs more to the group of firms with high values for a certain condition; values less than 0.5, are the opposite. In this method, the rule used to assess the relationship between the outcome and the variables analyzed is the inclusion rate, also called the "consistency score" (Longest; Vaisey, 2008). This is given by:

$$I_{XY} = \frac{\sum \min(x_i, y_i)}{\sum x_i}$$

Where X is the configuration of the predictor (i.e., AB), Y is the product (outcome), x_i defines each association in configuration X, and y_i denotes each association in the Y configuration.

Considering the conditional probability, the closer the unit is to the value of I_{XY}, the greater the consistency of the data when stating that X is a subseries that defines Y (X → Y). Several methods can be used to decide which configuration of X predictors is sufficient to explain Y. An important step is to define which configurations will compose the truth table. A first cut is to keep only configurations with I_{XY}> 0.800. In addition, configurations considered to be "contradictory" are also excluded from this table, that is, they explain both outcome Y and 1-Y. This elimination is based on the principle of asymmetric causality (Berg-Schlosser et al., 2009) and is performed by comparing the consistency of configuration X against outcome Y vis-a-vis the consistency of X with outcome 1 - Y. When this difference is not statically significant, this condition is considered contradictory, being disregarded in the assembly of the truth table (Longest; Vaisey, 2008).

With the truth table in place, an internal minimization procedure is implemented to identify sufficient minimum settings to explain outcome Y. These settings are evaluated in terms of their consistency (given by I_{XY}) and their coverage (C_{XY}), which is given by:

$$C_{XY} = \frac{\sum \min(x_i, y_i)}{\sum y_i}$$

Although similar to I_{XY}, it provides different information: it is seen as the portion of the sum of outcome Y covered by configuration X. This can be interpreted as analogous to the "portion of the variance explained" by this configuration (Ragin, 2006) or as the portion of the outcome that can be understood from the final configuration found (Longest; Vaisey, 2008). Ragin (2006) considers a C_{XY} above 0.2 to be adequate. Finally, the model allows the best configuration (or fit) to be presented for each observation (that is, a firm), considering its variables in comparison to the result Y and the other groups analyzed. All fsQCA procedures were implemented using the "fuzzy" program by Longest and Vaisey (2008) for Stata® software.

4 Results

The results are divided into two parts: (1) development of the indicators; (2) identification of the combinations between the organizational determinants sufficient for a high ACAP.

4.1 Development of the indicators

4.1.1 Indicators for Absorptive Capacity (ACAP)

To develop an indicator for ACAP, all the 18 items described in Table 1 are used together. It allows us (i) to test the division of ACAP proposed by Zahra and George (2002), and (ii) to maintain firms that replied 'unable to give an opinion' to any item of any dimension of ACAP. To define the number of principal components (i.e. the "indicators"), four analyses were carried out. The comparative results are shown in Tables 5 and 6.

Some points are important in choosing the solution. First, there are gains in the solution with 3 components over solutions with 1 or 2, either in terms of explained variance or high internal consistency of these (Cronbach's alpha close to or above 0.7)[5]. The 3-component solution also ensures that all variables are represented in at least one component (i.e., component loading close to or greater than 0.5), a condition not met in the other two analyses. Second, the solution with four components does not contribute to the interpretation and representation of the variables, given that: (1) the increase of Cronbach's alpha and variance explained is lower; (2) all variables had component loadings close or higher, in absolute values, for any of the other three components; (3) the internal consistency specific of the fourth component is less than 0.6.

Table 5
Quality of adjustment according to the number of indicators sought for ACAP

	1 indicator		2 indicators		3 indicators		4 indicators	
Principal Components	Cronbach's alpha	VE* (%)	Cronbach's alpha	VE* (%)	Cronbach's alpha	VE* (%)	Cronbach's alpha	VE* (%)
1	0.936	47.8%	0.928	44.8%	0.918	41.7%	0.911	39.8%
2			0.742	18.5%	0.733	18.0%	0.724	17.6%
3					0.698	16.3%	0.704	16.6%
4							0.512	10.8%
Total	0.936	47.8%	0.966	63.4%	0.982	76.1%	0.989	84.7%

Source: Own elaboration. Note: * VE indicates "Variance Explained"

(5) In Table 6, the 1-component solution is not analyzed because it represents less than 50% of the variance.

Table 6
Component loadings for each component of the three analyses to measure ACAP

Items	2 components		3 components			4 components			
	1	2	1	2	3	1	2	3	4
Ac_search_const	0.68	-0.47	0.71	-0.54	0.42	0.71	-0.41	0.51	-0.36
Ac_ident_ot_Univ_RI	0.96	-0.25	0.95	-0.21	-0.14	0.95	-0.20	-0.07	0.31
Ac_ident_ot_market	0.71	0.26	0.71	0.29	-0.02	0.63	0.25	-0.01	0.66
Ac_similar_know	0.80	-0.61	0.80	-0.60	-0.32	0.84	-0.60	-0.19	-0.16
As_resour_complem	0.91	-0.33	0.90	-0.26	-0.22	0.93	-0.24	-0.11	0.31
As_worker_interpret	0.53	0.75	0.53	0.76	0.04	0.45	0.76	-0.05	0.00
As_market_change	0.80	-0.60	0.77	-0.62	-0.31	0.83	-0.61	-0.19	-0.19
As_new_know_Univ_RI	0.87	-0.05	0.86	-0.01	-0.10	0.83	-0.09	-0.10	0.40
As_no_change_know_base	0.49	0.66	0.49	0.68	-0.16	0.38	0.63	-0.26	-0.45
T_adapt_tec	0.45	0.69	0.43	0.64	0.15	0.36	0.68	0.03	-0.12
T_worker_link_know	0.57	0.56	0.57	0.58	0.11	0.52	0.66	-0.01	0.04
T_change_know_base	0.05	-0.08	0.16	0.09	0.64	0.06	0.05	0.59	0.48
T_worker_use_know_pract	0.50	0.24	0.48	0.22	-0.28	0.50	0.26	-0.36	-0.11
E_const_search_aplly_know	0.79	0.12	0.80	0.12	-0.30	0.80	0.00	-0.27	-0.46
E_cap_use_new_know_changes	0.74	0.28	0.76	0.23	0.19	0.76	0.36	0.17	-0.19
E_apply_new_know_innov	0.72	-0.36	0.46	-0.27	0.80	0.31	-0.02	0.89	-0.24
E_improve_compet_market	0.35	0.15	0.23	0.06	0.62	0.21	0.18	0.59	0.33
E_work_more_effective	0.47	0.22	0.19	-0.16	0.89	0.17	0.04	0.90	-0.31

Source: Own elaboration. Note: The color is only to indicate the strength of a particular item in a given component, helping to interpret it. The greener the cell, the greater the importance of the item in a positive signal; the redder, the greater the importance, but with a negative relationship with the component.

Therefore, the solution with 3 components is chosen and presented again in table 7 below. This result has relevant theoretical implications.

First, it is noted that the **first component** is composed of items related to the acquisition and assimilation capabilities and some items to the exploitation capabilities. This result contradicts the division between "potential ACAP" and "realized ACAP" for the present context. However, these items for exploitation capability are aimed at "less specific and concrete" uses of external knowledge, such as reflecting on "how to apply external knowledge in innovations" (E_const_search_aplly_know) and "how to use them to react to changes in the environment" (E_cap_use_new_know_changes). These items reflect future or hypothetical applications of external knowledge. The exploitation capability items referring to more "effective, specific and targeted" applications of external knowledge are linked to the **third component**. These applications include: the ability to apply new knowledge to products and processes (E_apply_new_know_innov), leveraging skills or market share (E_improve_compet_market), and working more effectively (E_work_more_effective).

Table 7
Component Loadings of the final solution to measure the ACAP

Original Dimensions	Code	Variable description	Components		
			1	2	3
Acquisition capabilities (Ac)	Ac_search_const	The search for relevant information about our sector is constant in the day-to-day business of our company	0.71	-0.54	0.42
	Ac_ident_ot_Univ_RI	We easily identify technological opportunities at Universities or Research Institutes	0.95	-0.21	-0.14
	Ac_ident_ot_market	We easily identify the technological opportunities that arise in the market	0.71	0.29	-0.02
	Ac_similar_know	Our knowledge is similar to the knowledge generated by the external supplier, facilitating the identification and acquisition of external knowledge	0.80	-0.60	-0.32
Assimilation Capabilities (As)	As_resour_complem	The resources and capacities of the company and the external organization providing information and knowledge are complementary, facilitating the assimilation of new knowledge	0.90	-0.26	-0.22
	As_worker_interpret	Our workers can interpret external knowledge in a way that satisfies the company's objectives	0.53	0.76	0.04
	As_market_change	We quickly interpret, process and understand market changes that are important to our company	0.77	-0.62	-0.31
	As_new_know_Univ_RI	We quickly interpret, understand and process the new knowledge generated by Universities and/or Research Institutes	0.86	-0.01	-0.10
	As_no_change_know_base	To process and assimilate the new external knowledge, it was *not* necessary to substantially change the existing knowledge structure in the company.	0.49	0.68	-0.16
Transformation Capabilities (T)	T_adapt_tec	We can adapt technologies developed by others to the particular needs of the company	0.43	0.64	0.15
	T_worker_link_know	Our workers link the new knowledge obtained externally with the knowledge already existing in the company	0.57	0.58	0.11
	T_change_know_base	The processing of new external knowledge required a reconfiguration of the company's existing knowledge structure	0.16	0.09	0.64
	T_worker_use_know_pract	Our workers can apply new knowledge to their work practices	0.48	0.22	-0.28
Exploitation Capabilities (E)	E_const_search_aplly_know	We constantly consider how to better exploit external knowledge to generate innovations	0.80	0.12	-0.30
	E_cap_use_new_know_changes	We have capabilities that allow us to use and exploit new knowledge, in order to answer quickly to changes in the environment, and gain a competitive advantage	0.76	0.23	0.19
	E_apply_new_know_innov	We have the capabilities to apply new knowledge into new products and processes	0.46	-0.27	0.80
	E_improve_compet_market	The new external knowledge was essential for the company to leverage its competencies, increase its participation in its market, or reach new markets.	0.23	0.06	0.62
	E_work_more_effective	Our company can work more effectively through the adoption of new technologies and knowledge	0.19	-0.16	0.89

Source: Own elaboration. Note: The color indicates the strength of an item in a given component, helping to interpret it. The greener the cell, the greater the importance of the item in a positive direction; the redder, the greater the importance, but with a negative relationship with the component.

Thus, **Component 1** would be closer to an ACAP focused on what Lane, Koka and Pathak (2006) define as "exploratory learning". For this learning, the acquisition and assimilation of external knowledge expands the firm's knowledge base, giving greater flexibility to react more quickly to changes in the environment, including through possible future and hypothetical innovations. On the other hand, **component 3** would represent an ACAP linked to "exploitative learning", where the absorption of external knowledge is aimed especially at short-term results, more specific or concrete, such as market gains or to work effectively. These results refer to a greater firm's appropriability to absorb external knowledge (March, 1991; Lane; Koka; Pathak, 2006), but that also demand a change in the knowledge base for this ("T_change_know_base" with component loading equal to 0.64).

The **second component** suggests an ACAP not dependent on more organizational knowledge, either to identify or assimilate external knowledge, which is represented by the high and negative component loadings associated with the search for information (Ac_search_const) and similarities with external knowledge (Ac_similar_know). On the other hand, this ACAP is favored especially by individual abilities, either to interpret external knowledge or to combine it with previous knowledge, but without modifying the existing knowledge base. This "individual dependent" ACAP is not to innovate *stricto sensu*, but to adapt existing technologies, as shown by the high component loading for the item "T_adapt_tec".

Therefore, this second component may represent an ACAP to adapt existing technologies and be more dependent on the employees' abilities. This ACAP tends to be a result of the peculiarities of the context analyzed, i.e., the interaction with universities in Brazil. On the one hand, in general, firms focus essentially on adaptation and improving existing technologies, instead of on innovations *stricto sensu* (Pinho; Fernandes, 2015). On the other hand, the absorption of knowledge from universities depends heavily on individual abilities in this country (Negri, 2006; Teixeira; Rapini; Caliari, 2020).

Thus, the results of CatPCA for ACAP are not a clear division between potential ACAP and realized ACAP, since elements previously linked to different dimensions "mix" in different components. Thus, instead of identifying "dimensions" of ACAP, it was identified "types" of ACAP, linked to different strategies by the firm.

This difference against the literature may be due to four reasons: (1) CatPCA captured non-linear relationships that traditional factor analysis does not; (2) the database is composed of firms that had already interacted with universities before, which suggests a previous ACAP or an ACAP developed in it (Bisho; D'este; Neely, 2011), despite the limitations for this in Brazilian context (Rapini, 2009; Teixeira; Rapini; Caliari, 2020); (3) different motivations for interacting with universities (Fernandes et al., 2010) may end up reflecting different ACAPs; (4) the concept of ACAP as a dynamic capability of Zahra and George (2002) tends to be more appropriate for developed countries, where firms already have a developed and stronger knowledge base (Dutrénit, 2004). Therefore, these different results can be a reflection of the methodologies used here and also the Brazilian university-firm cooperative peculiarities, discussed before.

These three types of ACAP will be used as outcomes in the fsQCA analysis in section 4.2

4.1.2 Indicators for organizational determinants

As shown in Tables 2 and 3, the organizational determinants analyzed are divided into 5 groups *(and their respective abbreviation)*: (1) Strength and trust in the internal *(tsi)* and external

(tse) relationships; (2) Actions to disseminate external knowledge internally *(diss)*; (3) Degree of internal hierarchy *(h)*; (4) Employee participation in innovative projects *(workProj)*; (5) Formalization and Routines to absorb external knowledge *(r)*. These determinants will be divided into three CatpCA: (a) to build an indicator for strength and trust in internal relations and (b) another for external relations; (c) indicators for the other determinants.

This division has theoretical motivation. The analyses *a* and *b* focus on characteristics that affect ACAP indirectly or "unintentionally" (Ebers; Maurer, 2014), and they are not results of managerial decisions necessarily. In addition, these are more subjective variables than the other determinants. Tables 8 and 9 present the results for these analyses, suggesting one indicator for each, given the high Cronbach's alpha, explained variance, and component loadings.

Table 8
Indicator for strength and trust in internal relations

Code	Description of variable	Component Loadings
tsi_freq_communic	People responsible for innovation and other colleagues in the company communicated very often with each other	0.811
tsi_proffesional_ compet_action	People responsible for innovation and other colleagues in the company could always trust that each other would decide and act professionally and competently	0.951
tsi_receive_info	People responsible for innovation and other colleagues in the company could always trust that each would receive necessary and reliable information and service	0.912
tsi_keep_promises	People responsible for innovation and other colleagues in the company could always trust that each would keep the promises	0.819
Quality of adjustment	Cronbach's alpha	0.898
	Total variance explained (%)	76.62%

Source: Own elaboration.

Table 9
Indicator for strength and trust in external relations

Code	Description of variable	Component loadings
tse_interac	There is interaction between the people of the two organizations	0.936
tse_high_reciprocity	The relationship between our company and the external organization is characterized by a high degree of reciprocity	0.924
tse_freq_communic	Communication is frequent between our company and the external organization	0.918
tse_mutual_trust	The relationship between our company and external organizations is characterized by mutual respect and trust	0.852
Quality of adjustment	Cronbach's alpha	0.929
	Total variance explained (%)	82.47%

Source: Own elaboration.

On the other side, the analysis *c* focuses on determinants that generally require managerial decisions to be implemented and can be designed specifically to affect the dissemination of knowledge internally and the ACAP. Table 10 shows the quality adjustment for analysis *c*, indicating gains in using more than one component, both in terms of explained variance and new components with reasonable internal consistency. To decide about two or three indicators, the

component loadings are compared between the solutions, identifying that the item "workProj_tec_raise_part" would be only represented in the third component[6]. Therefore, the solution with two indicators is adopted because (i) the objective of CatPCA is to create "super conditions" to be used in the QCA and (ii) this solution presents indicators with high internal consistency and represents approximately 60% of the variance. This solution is shown in Table 11 below.

Table 10
Quality of adjustment according to the number of indicators sought for the "managerial" organizational determinants of ACAP

	1 indicator		2 indicators		3 indicators	
Principal Component	Cronbach's alpha	VE(1) (%)	Cronbach's alpha	VE(1) (%)	Cronbach's alpha	VE(1) (%)
1	0.900	37.1%	0.892	35.2%	0.886	34.1%
2			0.795	22.3%	0.794	22.2%
3					0.597	12.7%
Total	0.900	37.1%	0.957	57.5%	0.974	69.0%

Source: Own elaboration. Note: (1) "VE" indicates "Variance explained".

Table 11
Final decision: Component loadings for the two indicators for managerial organizational determinants of ACAP

Determi-nants	Code	Description	Principal Components	
			1	2
Actions to disseminate external knowledge internally (diss)	diss_informal_ contact	Informal contact among employees	0.65	0.03
	diss_develop_ innov_strategy	Development of innovation strategies	0.72	0.16
	diss_mutual_ support	Mutual support of other areas of the company with innovation-related problems	0.22	0.92
	diss_regular_ meet_managers	Regular meetings between managers from several areas of the company to discuss topics related to innovation	0.17	0.58
	diss_workshop	Seminars and workshops for innovation projects involving several areas of the company	0.20	0.92
	diss_job_ rotation	The exchange of personnel between departments or functions occurs regularly (e.g. the use of the techniques of job rotation)	0.31	0.57
Degree of internal hierarchy (h)	h_worker_ restricted_tasks	Employees perform a restricted range of tasks, featuring a strong division of labor.	-0.27	0.67
	h_dep_no_ freedom	The hierarchy is very extensive from the bottom to the top, with little freedom for each departmental level to make decisions	-0.29	0.57
	h_high_drive _action	High levels of the hierarchy drive the decisions and actions of the departments	-0.08	0.86

To be continued…

[6] This comparison is available upon request.

Table 11 – Continuation

Determi-nants	Code	Description	Principal Components	
Employee participation in innovative projects (workProj)	workProj_high_influen	Employees have a high degree of influence over the actions of the innovative projects of the company.	0.87	0.07
	workProj_implement_decision	Employees are allowed to implement many decisions in the process of generating innovation	0.77	0.04
	workProj_tec_raise_part	The techniques of Quality Circles, Methods of Analysis and Solve Problems (ex.: MASP, fishbone, 5W2H, cause-effect diagram) were important to promote the participation of employees in the company's innovative projects	0.42	0.05
	workProj_idea_bank	The "Bank of Ideas" was important to bring employees closer to the company's innovative projects	0.79	-0.16
	workProj_reward_idea	Employees are rewarded for implementing suggestions and ideas	0.87	-0.19
Formalization and Routines to absorb external knowledge (r)	r_training	The training focused on innovation is constant in our company	0.81	-0.14
	r_formal_proc_search_assimi	Our company has formalized processes in documents (physical or electronic) that help in the search, acquisition, and understanding of external knowledge	0.54	0.04
	r_rules_doc_use_know	Our company has explicit rules on documents (physical or electronic) that help in using this knowledge to generate innovation	0.75	-0.01
	r_encourage_proto	The manager encourages the development of prototypes	0.78	-0.14

Source: Own elaboration. Note: Note: The color is only to indicate the strength of a particular item in a given component, helping to interpret it. The greener the cell, the greater the importance of the item in a positive direction; the redder, the greater the importance, but with a negative relationship with the component.

The **first component** is related to the variables linked to the participation of employees in innovative projects (variables started in "workProj_"), combined with informal contacts between them and the realization of internal training. This labor participation seems to respond to innovation strategies and to be supported by managers and explicit rules that drive the use of external knowledge in this process[7].

The second component is related to variables referring to the degree of internal hierarchy (variables beginning with "h_"), where high values indicate a high degree of internal hierarchy. This component is also marked by more formal practices for the dissemination of knowledge between departments, such as regular meetings between managers, mutual support between different areas, workshops for innovation projects, and the use of job rotation. However, this component 2 has a weak relationship with the development of innovation strategies ("diss_develop_innov_strategy").

Therefore, there is a distinction between the indicators for the managerial organizational determinants of ACAP. **Component 1** is associated with organizational processes that promote and qualify employee participation in projects that follow a specific innovative strategy and guiding rules. **Component 2**, on the other hand, indicates more structural characteristics of the

(7) This is represented by component loadings above 0,7 for the variables "diss_develop_innov_strategy", "r_encourage_proto" and "r_rules_doc_use_know".

firm, where the dissemination of knowledge internally takes place in a more hierarchical organizational environment and through more formal processes for this, but without having an explicit relationship with an innovation strategy.

Using Jansen, Van den Bosch and Volberda (2005) and Van den Bosch, Volberda and De Boer (1999), we can interpret **Component 1** as an indicator of the combination of coordination and system capabilities. The first is linked to the participation of the workforce in innovative projects and training, while the second, with the existence of explicit rules to direct the use of external knowledge. **Component 2**, on the other hand, indicates the use of combinative capabilities (via job rotation, internal workshops, etc.) to disseminate knowledge in a more hierarchical organizational environment, thereby increasing the scope of the ACAP, which would otherwise be reduced by this hierarchical structure.

4.2 fsQCA results

The indicators from the previous sections will be employed in the analysis of the fsQCA. The role and summary of each indicator are presented in Table 12.

Table 12
Summary of the variables for fsQCA

Role and Code in fsQCA		Results of CatPCA			
Role	Code*	Indicator	Cronbach's alpha	Result table	Simple description
Outcomes	X	ACAP 1	0.918	7	ACAP focused on *Exploratory Learning*
	Y	ACAP 2	0.733		Employee-dependent ACAP and focused on adapting existing technologies
	Z	ACAP 3	0.698		ACAP focused on *Exploitative Learning*, seeking short-term, direct or specific results
Conditions	A	Managerial organizational determinants 1	0.892	11	Organizational processes that promote and qualify the employee participation in innovative strategic projects that follow guiding rules.
	B	Managerial organizational determinants 2	0.795	11	High internal hierarchy, combined with formal processes to disseminate knowledge internally, not related to an explicit innovation strategy.
	C	Internal trust	0.898	8	Trust and strength in internal relations
	E	External trust	0.929	9	Trust and strength in external relations

Source: Own elaboration. Note: *These codes refer to indicators of the third column transformed into fuzzy sets.

Three separate analyses will be studied, seeking to identify, for each type of ACAP, the sufficient minimum configurations among the organizational determinants. For this, the first step was to transform these indicators into *fuzzy* sets through standardization so that they vary between 0 and 1, preserving the position of firms in the distribution of a given variable. These transformed variables are represented by a single uppercase letter (see the second column of Table 12). In the analysis, uppercase letters denote variables with a score of association above 0.5, while lowercase

letters indicate scores below 0.5. To exemplify this transformation, one can look at the indicator ACAP 1 (item X in the fsQCA): when the company has a score of association above 0.5 for ACAP 1, it will be interpreted that this company has a high ACAP 1 (represented by 'X'); when this value is less than 0.5, it is said to have a low ACAP 1 (represented by 'x').

The considered "conditions" allow for 16 logically possible configurations that would compose the truth table[8]. However, not all of these logically possible configurations should be considered in the analyses, especially in relatively small databases (LONGEST; VAISEY, 2008; RAGIN, 2009). Three criteria were adopted for this exclusion: (1) the configuration is logically possible, but it was not observed in the database; (2) it is a contradictory configuration[9]; (3) the configuration did not show a consistency score statistically higher than 0.8. In all cases, the significance level of 10% was considered.

Table 13 depicts the sufficient minimum configurations for each ACAP and the accuracy of the final adjustment. The three minimum configurations for each ACAP presented high final consistency (above 0.8 each) and a satisfactory coverage rate (Ragin, 2006). Therefore, these configurations can be considered as sufficient conditions and will be interpreted as "minimum organizational configurations" to obtain a certain high ACAP.

Table 13
Minimum organizational configurations sufficient to obtain high levels of each ACAP

	Outcome (simple description)	Minimal Configuration	Consistency score	Coverage	Number of cases(1)
1	High ACAP 1 (*Exploratory learning*)	C*E	0,865	0,689	13
2	High ACAP 2 (Technology adaptation)	A*C*E	0,858	0,542	8
3	High ACAP 3 (*Exploitative learning*)	A*B*C*e	0,963	0,224	2

Source: Own elaboration.
Note: (1) The number of firms that presented a certain minimum configuration for the outcome.

These minimal organizational configurations allow for three following logical relationships:

(1) If the company combines strong and reliable internal and external relationships (conditions "C" and "E"), regardless of the organizational management processes (indicated by the absence of conditions A and B in the minimum configuration), then the company has a high ACAP 1 (focused on exploratory learning).

(2) If the firm combines highly trustworthy internal (C) and external (E) relationships with organizational processes that favor and qualify the participation of employees in the execution of strategic innovative projects (A), regardless of the degree of internal hierarchy

(8) For example, a company has the configuration "ABCE", which means that it has a high labor force participation in strategically innovative projects (represented by "A"), high internal hierarchy with formal practices to disseminate knowledge internally (represented by "B") and high trusting internal and external relationships (represented by "C" and "E"). Another company presents the configuration "ABce", being different from the former because of less reliable internal and external relationships (represented by "c" and "e").

(9) These "contradictory configurations" do not present a consistency score significantly superior for a given high ACAP in comparison with the consistency score for the same ACAP at a low level.

(indicated by the absence of condition "B"), so the company has high ACAP 2 (focused on the adaptation of technologies);

(3) If the firm combines low external trustworthy relations (e) with strong internal confidence (C), high internal hierarchy (B) and also high employees' participation in innovative strategic projects (A), then the company has high ACAP 3 (focused on exploitative learning and results of greater knowledge appropriability).

These logical relationships imply theoretical discussions.

First, the minimum configurations for a high ACAP 2 are a subset of the minimum configurations for a high ACAP 1. This has important theoretical implications for the interpretation of the knowledge absorption process when analyzed together. To build an ACAP aimed at expanding the knowledge base without a defined application (i.e. ACAP 1), the combination of strong external and internal personal relationships is sufficient. The first allows employees linked to the innovative process to act as gatekeepers, accessing external knowledge more easily and bringing it to the company. However, for the assimilation in the internal knowledge base, the external knowledge needs to be disseminated and shared internally in the company (Cohen; Levinthal, 1990). In the present study, this is done through strong internal personal relationships (Ebers; Maurer, 2014) and does not necessarily depend on more managerial organizational processes. These processes, in turn, are necessary when the company seeks to build capabilities to adapt existing technologies, that is, to have a high ACAP 2. For this, the company must combine strong internal and external relationships with organizational processes that favor, qualify, and direct the participation of the employees in strategic innovative projects (i.e., the "presence of "A" in the final solution, together with "C" and "E"). These actions, when combined, can be seen as intra-firm "pipelines" (Lane; Koka; Pathak, 2006) that allow to connect workers internally, disseminate external knowledge internally and direct the application of external knowledge (Ebers; Maurer, 2014; Vega-Jurado; Gutiérrez-Gracia; Fernández-De-Lucio, 2008).

In other words, the results suggest that, when the firm seeks to access new knowledge without a defined application, only personal relationships can be sufficient; but, when seeking to exploit this knowledge to adapt technologies, managerial organizational processes are necessary for employee participation. These processes can be seen as a way of connecting individual actions and stimulating the exploitation of external knowledge, making ACAP less dependent on individual characteristics (Lewin; Massini; Peeters, 2011). It is worth mentioning that ACAP 2, in addition to focusing on the adaptation of technologies, is also dependent on individual skills, but it demands internal processes that induce the application of them.

The second interesting result refers to ACAP 3, which focused on the application of external knowledge in short-term, specific, and more direct results. To have a high ACAP 3, the company needs to balance the low confidence in external relations (represented by "e") with the combination of a high internal hierarchy ("B") with managerial organizational processes ("A") and internal relations ("C") that connect the members of the company, favor their participation in the innovative process and the consequent dissemination of knowledge within this more hierarchical structure. Van den Bosch, Volberda and De Boer (1999) already suggested that a more hierarchical organizational structure led to greater efficiency in absorbing external knowledge, but a smaller scope of it. This is in line with this ACAP 3 focused especially on more specific results, such as "working more effectively" and "gaining market share", unlike ACAP 1 (focused, for example, on responding more quickly to changes in the market and having flexibility in the use of knowledge in innovations). However, given that ACAP 3 is also associated with the

modification of the internal knowledge base[10], the high hierarchy is not enough for this. Processes related to the coordination capacity among members are necessary to counterbalance the loss of scope and flexibility brought about by this higher hierarchy (Van Den Bosch; Volberda; De Boer, 1999). In short, the high hierarchy allows for some efficiency in the application of external knowledge in more specific results, but the other organizational processes for the participation of the employees in innovation and the strong internal relations favor the scope and flexibility necessary for the ACAP 3.

5 Final remarks

This paper delves into an analysis of how firms engaged with research groups in Brazil develop their Absorptive Capacities (ACAP) through the combination of various organizational determinants. These determinants encompass factors such as the strength and trust in internal and external interactions, the degree of hierarchy and internal formalizations, internal practices concerning knowledge dissemination, and labor participation in innovative projects. To achieve this, a custom database was employed, complemented by non-linear Categorical Principal Component Analysis (CatPCA) and fuzzy-set Qualitative Comparative Analysis (fsQCA) methodologies.

Limited to the context analyzed—firms that interacted with universities in Brazil—the results suggest an unforeseen partial connection between firms' strategies, types of ACAP, and the minimum organizational configurations for these. In this study, firms that focus on exploratory learning, seeking external knowledge mainly to expand their existing knowledge base, build their ACAP (ACAP 1) by combining internal personal relationships of trust with external ones. On the other hand, firms that build their ACAP to adapt existing technologies (ACAP 2), need to combine these strong personal relationships (internal and external) with organizational processes in favor of employee participation in projects linked to this innovative strategy. Finally, firms that seek more immediate results and more direct appropriability, focused on exploitative learning (i.e., ACAP 3), depend essentially on strong internal knowledge and relationships and also depend on the internal dissemination of knowledge, guided by a strong intra-firm hierarchy that brings efficiency in the application of external knowledge.

These findings trigger insightful considerations. Firstly, they delve further into the organizational perspective of capability development (Paranhos; Hasenclever, 2021), spotlighting the notion that different firms can possess distinct organizational configurations". This implies that they can blend organizational determinants differently yet achieve comparable capability levels, given they adhere to a "minimum configuration" (as demonstrated by fsQCA). Such outcomes reinforce the nexus between ACAP and the concept of organizational capabilities, viewing it as an outcome derived from various permutations of intra-firm routines.

Second, the articulation between firm strategy, types of ACAP, and organizational configurations is close to Nelson (1991) explanation of the source of heterogeneity among firms: firm strategy, internal structure, and core organizational capabilities. Further research may evaluate this relationship using a broader database and specifically investigate these strategies. This expanded analysis would allow us to analyze, for example, whether firms seek those types of ACAP or whether it is what they get from their existing internal resources. This could be a research agenda.

(10) It is worth remembering that ACAP 3 is also composed of the item directly connected to the change in the internal knowledge base through external knowledge ("T_change_know_base").

In addition, these results also reinforce the heterogeneity of ACAP of firms that interacted with universities in Brazil. As discussed before, in the Brazilian context, there is a heterogeneity of firms' strategies to interact with universities, including an interaction to substitute firms' internal R&D activities, which is an engagement type that limits the possibility of developing ACAP. This paper emphasizes the importance of considering Brazilian heterogeneity in ACAP analysis and highlights the fsQCA as a valuable method for this purpose.

Finally, this study underscores the importance of individual abilities in firms interacting with universities in Brazil, particularly regarding ACAP 2, which reflects the specific characteristics of the analyzed context. However, these particularities limit the generalizability of the results, necessitating further studies and broader surveys on the subject.

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