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Absorptive capacity activation triggers: Insights from learning in project epochs of a project-based organization

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ABSTRACT

Operating in an environment of rapid technological changes, project-based organizations need to stay continuously updated and, therefore, must develop absorptive capacity. This research introduces an innovative theoretical framework for the development of absorptive capacity within project-based organizations. However, this capability is often developed in an unplanned manner, as it is stimulated by what the literature calls activation triggers. By analyzing 54 significant automation projects across seven epochs, this study spans 25 years of a project-based organization. It reveals four knowledge sources of absorptive capacity and its activation triggers, classified into six groups. The framework underscores the strategic importance of activation triggers and offers valuable insights into the dynamics of absorptive capacity, emphasizing the significance of relationships with clients, technology partners, and strategic business partners, as well as the role of project-based learning. These findings provide practical implications for enhancing innovation and achieving sustainable success in project-based organizations.

1. Introduction

Project-Based Organizations (PBOs) are companies where the main products or services are produced through projects, managing multiple ongoing projects to optimize resource allocation and efficiency (Zhou et al., 2022). They provide unique services and products to meet customer needs, with revenue dependent on project execution, making project management central to their competitive posture (Blindenbach-Driessen & Van Den Ende, 2010; Fang & Zhang, 2021; Zerjav, 2021; Söderlund, 2005). PBOs handle various project types, including those tailored to customer specifications and aimed at developing new technologies across industries like construction, telecommunications, shipbuilding, mining, information systems, industrial automation, oil and gas, and energy systems (Gann & Salter, 2000; Sydow et al., 2004). Their design, characterized by simultaneous or successive projects, is often complex and challenging to manage (Engwall & Jerbrant, 2003; Hobday, 2000).

Additionally, PBOs face challenges in consistently achieving high performance in project execution over time because the temporary nature of projects poses a barrier to learning and transferring acquired knowledge, among other factors (de Souza et al., 2021; Duffield & Whitty, 2016; McClory et al., 2017). Pemsel et al. (2018) emphasize that in order to effectively capture and execute projects, PBOs must continually strive to learn from similar recurring projects. However, due to market and technological changes, as well as the demand for innovation relying solely on project-based learning is often insufficient (Agarwal & Helfat, 2009; Ferreira et al., 2020; Mainga, 2017).

In this sense, PBOs must broaden their learning horizons by seeking knowledge from external companies with more advanced expertise in technology, management systems, and coordination (Bakker, 2016). In the realm of PBOs, knowledge stands as their most valuable asset, one that needs to be continually created, developed, and protected. Forming strategic alliances with partners possessing the required knowledge can compensate for the lack of market and technological understanding, reducing risks and costs while enhancing project capabilities (Bakker, 2016; Burgers et al., 2008; Deep et al., 2023; Kivilä et al., 2017; von Danwitz, 2018). Thus, it is mandatory for PBOs to develop their absorptive capacity (AC).

AC refers to a firm's capability to recognize the value of new external information, assimilate it, and apply it for commercial purposes (Cohen & Levinthal, 1990). Zahra and Gorge (2002) enhanced the AC model by introducing the concept of activation triggers. Activation triggers

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represent events that prompt a firm to react to specific stimuli necessitating knowledge not presently within the organization's reach. Essentially, an activation trigger motivates a firm to invest resources in developing the ability to acquire and assimilate externally generated information, thereby enhancing its AC and consequently facilitating new knowledge development, fundamental to PBOs (Flor et al., 2018; Fosfuri & Tribó, 2008).

Recent studies have associated AC with competitive advantage (Acosta-Velásquez et al., 2022; Ferreras-Méndez et al., 2015; Vicente-Oliva et al., 2015), as well as its role in driving innovation (Alves & de Carvalho, 2023; Enkel et al., 2017; Flor et al., 2018; Kanwal et al., 2019; Urbinati et al., 2020), and improvement in project performance (Ali et al., 2018; Bjorvatn & Wald, 2018; Love et al., 2016; Singh et al., 2023; Vlačić et al., 2019). Due to the inherent complexities in PBOs, AC is often developed in an unplanned manner, stimulated by specific activation triggers (Ahern et al., 2014; Jansen et al., 2005; Todorova & Durisin, 2007). However there is limited exploration of its implications for these organizations in the literature (Kanwal et al., 2019).

Therefore, because the PBO constantly needs to renew its knowledge and recognizing the significance of applying AC to foster innovation through updating this knowledge, this article investigates the activation triggers that stimulate ACs within PBOs and identifies the knowledge sources that accelerate their application (Ferreras-Méndez et al., 2015; Flor et al., 2018). Additionally, it explores the relationship among different sources of AC and the PBOs.

To achieve this objective, the article is divided into six sections. Following the introduction, the second section presents comprehensive overview of the concepts of PBO, AC, project epochs, and triggers through a literature review. The third section describes the research method, an in-depth retrospective case study conducted in a PBO specializing in automation projects, analyzing 25 years of project execution experience. This approach integrates interviews, group dynamics and archival data, offering a unique advantage for exploring AC within PBOs based on a comprehensive understanding of knowledge absorption and project execution evolution, facilitating the capture of detailed insights into AC dynamics.

The fourth section presents the case study results. Following the framework proposed by Söderlund and Tell (2009), the study identified seven project epochs, enabling a historical and retrospective analysis that contributes to the understanding of AC in PBOs. Through interviews and in alignment with these project epochs, the case study revealed 54 significant projects that played a crucial role in the development of AC within the company.

The study findings provide novel insights into the critical role of activation triggers in fostering organizational learning. We identified six categories of activation triggers: economic conditions and competitiveness, business strategy and expansion, innovations and technology, technological shifts and adaptation, partnerships and relationships, and project experience and learning. These categorizations led to the identification of four specific sources of AC, each based on different sources of knowledge acquisition: client, technology partner, strategic business partners, and project execution.

The fifth section presents a discussion. The selected projects provided insights into the central question of the study: "What triggers the absorptive capacity in PBOs?" by conducting a comprehensive analysis of the sources of the activation triggers (Zahra & George, 2002). Building on these insights, this section introduces an innovative theoretical framework for AC development within PBOs. This framework offers valuable strategies for managers, leaders, and project managers, focusing on enhancing the organization's capacity for knowledge absorption and building effective relationships that drive innovation and contribute to overall success.

The conclusions in the sixth section highlight the critical role of external knowledge sources and elucidate how the nature and quality of relationships significantly influence the learning process within PBOs. Limitations and suggestions for future studies are also discussed in this section.

2. Literature review

2.1. Project-based organizations and project epochs

PBOs are companies structured around projects, delivering customized services and products tailored to meet customer needs (Blindenbach-Driessen & Van Den Ende, 2010; Fang & Zhang, 2021; Zerjav, 2021). Their revenue hinges on the successful execution of projects, placing project management and project competence at the core of their competitiveness (Bakker et al., 2011; Söderlund, 2005). PBOs engage in a diverse range of project types, including customer-specific projects and projects focused on developing new technologies (Gann & Salter, 2000; Popaitoon & Siengthai, 2014; Sydow et al., 2004). Their key activities involve design, project management, systems engineering, and systems integration (Mainga, 2017; Popaitoon & Siengthai, 2014).

Learning from projects enhances knowledge and performance in PBOs (Ali et al., 2016; Kanwal et al., 2019; Moraes et al., 2020). In a sequence of projects, the first one can serve as an exploratory endeavor, generating insights and learning that can be applied to subsequent projects in a longitudinal interdependence, while follow-up projects provide opportunities for seizing new advancements (Kock & Germuenden, 2019). On the other hand, achieving consistent performance over time in project execution is challenging for PBOs, mainly due to the temporary nature of projects, which creates barriers to knowledge transfer and learning (Ajmal & Koskinen, 2008; de Souza et al., 2021; Duffield & Whitty, 2016; McClory et al., 2017; Söderlund, 2005). Despite this, PBOs must adapt and learn from recurring projects (Mainga, 2017; Moraes et al., 2020; Pemsel et al., 2018). As a result, there should be a dual continuous learning flow: from the organization to projects and from projects to the organization (Hermano & Martín-Cruz, 2020; Löwstedt et al., 2018).

On the other hand, due to rapid technological changes in the market and the increasing demand for innovation, relying solely on project-based learning is insufficient for PBOs (Agarwal & Helfat, 2009; Ferreira et al., 2020; Mainga, 2017). These organizations must expand their boundaries and engage in learning from external companies that possess advanced expertise in technology, management systems, and coordination (Bakker, 2016). Therefore, PBOs should not disregard external technology but rather develop their AC (Teece, 2007). It is essential for these companies to broaden their AC by not only learning from project execution but also by capturing external knowledge through alliances and partnerships formed to execute projects (Deep et al., 2021; Ojo et al., 2017).

Söderlund and Tell (2009) introduced the concept of project epochs in their study to comprehend the learning processes within and across projects, improvements made in project operations, and insights into dynamic capabilities within project management. The identification of project epochs can enhance the understanding of capability building in PBOs. Analyzing how organizations develop project capability requires examining specific projects as well as the development and evolution of the studied company (Biedenbach & Müller, 2012; Söderlund & Tell, 2009).

Project epochs can arise from the initiative of the PBO itself or result from unique strategic partnerships. These project epochs facilitate a period of learning from past projects, which Salunke et al. (2019) refer to as episodic learning capability—a PBO's capacity to deliberately create new knowledge based on past project experiences, extend that knowledge to value-creating activities, and adapt it to address changing market conditions. We argue that by identifying these project epochs, it becomes possible to identify the relevant projects responsible for the development of AC during each period, as well as the key contingencies that stimulate the development of these capacities.

2.2. Absorptive capacity definitions

Cohen and Levinthal (1990) define AC as a firm's capability to recognize the value of new external information, assimilate it, and apply it for commercial purposes. AC is a critical factor for a firm's innovative capabilities. AC is largely dependent on the firm's level of prior related knowledge, which can encompass fundamental skills or knowledge of the latest scientific or technological developments in a specific field. Without adequate prior knowledge, external information may not be perceived as relevant or fully understood by the organization. Prior knowledge plays a critical role in enabling the organization to assess the relevance and applicability of new information, facilitating its incorporation into existing processes, and enabling the creation of new knowledge or enhancement of existing ones (Cohen & Levinthal, 1990).

For Zahra and George (2002), AC is a multidimensional construct that encompasses the processes of knowledge acquisition, assimilation, transformation, and exploitation, enabling firms to develop dynamic organizational capabilities and foster innovation. It is important to note that these capabilities are idiosyncratic in nature, as they are shaped by the firm's unique resources and actions (Fabrizio, 2009; Zahra & George, 2002). This notion of AC as a multidimensional construct sets the stage for recent contributions from the literature, which delve into its practical implications.

Table 1 summarizes recent research on AC within project and organizational contexts, highlighting its role in business sustainability, project innovation, and performance measurement. While Singh et al. (2023), Mainga (2017), and (Ahankoob et al. (2021) focus on PBOs, they do not explore activation triggers. Singh et al. (2023) examined potential and realized AC and social processes in PBOs. Mainga (2017) identified factors hindering knowledge transfer in PBOs, such as inadequate AC and relational challenges. Ahankoob et al. (2021) studied BIM's impact on AC, enhancing PBO competitiveness. Other studies, like those by Love et al. (2016) and Boroomand & Chan (2022), focus on broader organizational contexts and do not address PBO-specific needs, highlighting the importance of this study.

Due to the turbulent nature of the business environment and the increasing availability of external knowledge sources, AC has emerged as an essential dynamic capability to seize opportunities and servers as a critical driver of competitive advantage (Barbosa & Carvalho, 2023). It enables firms to effectively identify, assimilate, and deploy from absorbed external knowledge essential for fueling internal innovation processes (Fabrizio, 2009; Fosfuri & Tribó, 2008; Jansen et al., 2005). Unlike learning-by-doing, which focuses on improving existing knowledge, AC empowers firms to acquire the capabilities to generate new knowledge and accurately anticipate future technological advancements (Lane et al., 2006; Schneckenberg et al., 2015)

2.3. Challenges for developing absorptive capacity

For firms to successfully apply targeted knowledge, they must develop processes to explore, transform, and exploit it. However, these processes are neither automatic nor easy (Ferreras-Méndez et al., 2015; Flor et al., 2018; Lane et al., 2006). In the context of PBOs, the temporary nature of projects further accentuates the need for AC, while also presenting additional challenges. For instance, when a project concludes and participants move on, the knowledge created during the project is prone to dispersal (Bakker et al., 2011; Moraes et al., 2020). This complicates the transfer of knowledge from project to project (Wei & Miraglia, 2017).

Moreover, the continuous formation and dissolution of project teams, with significant variations in their duration, result in constant changes in workgroups, adding complexity to the effective management of the interorganizational dynamics of PBOs (Mathew et al., 2023). Despite this reality, PBOs must actively recognize, capture, and assimilate knowledge from both successful and failed projects, drawing lessons learned from various sources. This knowledge must then be applied

Table 1
Recent studies of AC in project and organizational context.

Theme	Description	Reference
PBOs and AC	Explore the role of AC in PBOs, introducing concepts of potential and realized AC and investigating how social processes moderate the relationship between potential AC and project performance.	(Singh et al., 2023)
Knowledge Management and AC	Investigate how the continuous "lessons learned" process enhances AC, improving the safety and quality performance of the projects.	(Love et al., 2016)
	Investigate the impact of knowledge AC on project innovativeness and explore how internal and external social capital influence this relationship.	(Kanwal et al., 2019)
	Identify determinants of "stickiness" in knowledge transfer in PBOs: recipient's inadequate AC, causal ambiguity, and challenging relationship between knowledge source and recipient.	(Mainga, 2017)
	Examine the relationship between AC and its knowledge dimensions, demonstrating that a formative model better represents these relationships, highlighting the cumulative development of AC over time.	(Knoppen et al., 2022)
	Highlight the importance of AC by focusing on how firms acquire and exploit external knowledge for innovation, introducing the concept of digital AC and developing a measurement tool to assess its role.	(Boroomand & Chan, 2022)
	Investigate the relationship between knowledge governance, sharing, AC, and project performance, with social processes moderating these relationships.	(Ali et al., 2018)
	Investigate the role of good knowledge governance and tacit knowledge sharing in boosting a project's AC along with social dynamics modifying the link between AC, tacit knowledge sharing, and project results.	(Boamah et al., 2023)
	Delve into AC microprocesses regarding the acquisition phase relevant to project management knowledge identification, categorizing processes into events, social interaction, and tool utilization.	(Moraes et al., 2020)
Dynamic Capabilities and AC	Explore the synergy between dynamic capabilities, AC, and knowledge management to drive innovation in projects.	(Alves & de Carvalho, 2023)
Open innovation and ACs	Contribute to inbound open innovation by identifying key practices for enhancing AC in open innovation projects.	(Urbinati et al., 2020)
	Examine the interplay between open innovation strategies, AC, and radical innovation outcomes in high-technology firms, showing potential and realized AC moderates the relationship between external search breadth and radical innovation.	(Flor et al., 2018)
Performance and ACs	Explore how the Performance Measurement System design influences AC in innovative firms.	(Bedford, et al., 2022)
	Examine how AC influences the performance and innovation outputs of technology-driven firms, finding a positive link between AC levels and innovation performance.	(Vlačić et al., 2019)
	Examine the relationship between project complexity and the impact of	(Bjorvatn & Wald, 2018)

(continued on next page)

Table 1 (*continued*)

Theme	Description	Reference
	project team AC on project management performance.	
Individual and team level AC	Unveil the crucial link between individual-level AC and the firm's innovation strategy, providing insights to optimize organizational innovation by strategically positioning individuals in the external search process.	(Enkel et al., 2017)
	Explore the micro-level drivers of AC within asymmetric joint project engineering teams, highlighting individual and team dimensions of AC and emphasizing the importance of prior experience and shared understanding.	(Ojo et al., 2017)
BIM adoption and AC	Examine the impact of Building Information Modeling (BIM) adoption on AC, confirming a significant correlation between BIM's transparency function and contractor AC, thereby enhancing PBO competitiveness.	(Ahankoob et al., 2021)

to the management of future projects, constituting a vital component of AC (Moraes et al., 2020). Consequently, PBOs must possess the ability to generate and assimilate new knowledge to adapt to market changes and incorporate that knowledge into the development of ongoing projects (Salunke et al., 2019; Vicente-Oliva et al., 2015).

While high-technology companies may initially hesitate to share knowledge, forming alliances with knowledgeable partners offers a means to develop AC within PBOs (Srivastava et al., 2015). These alliances help PBOs overcome potential gaps in market and technological knowledge, reducing risks and costs while enhancing project performance. Consequently, PBOs can proactively generate knowledge through project execution and interactions with stakeholders, continually adapting their capabilities to changing market conditions (Bakker, 2016; Burgers et al., 2008; Kafouros et al., 2020; Kivilä et al., 2017; Moraes et al., 2020; Salunke et al., 2019).

2.4. The influence of relationships in absorptive capacity

The cooperation between partner companies promotes the exchange of knowledge, experiences, and ideas, stimulating innovation through the integration of diverse knowledge domains and facilitating more comprehensive business and technology-related insights. Firms are increasingly reliant on knowledge acquired from other firms to enhance the development of their own capabilities, which aligns with the concept of AC (Kanwal et al., 2019; Lane & Lubatkin, 1998; Ojo et al., 2017). The knowledge acquired through these channels contributes to the potential AC. A critical challenge in this context is cultivating mutual trust among external partners as team members interact, exchange knowledge, and communicate directly with one another (Singh et al., 2023)

In this regard, it is critical for companies to manage their partnerships effectively (Barbosa et al., 2019). According to Deep et al. (2021), ensuring a fair allocation of risks is indispensable, as unequal distribution can hinder collaboration, leading to negative effects on trust, commitment, and reliability among project participants. The commitment of involved parties is essential for establishing solid and enduring relationships, while reliability is influenced by various factors such as the nature of the relationship, communication failures, and regionalism. For Takey and Carvalho (2015), complex contexts like consortium and engineering, procurement, and construction (EPC) projects, improve flexibility, risk management, resilience, and adaptability, especially when partnering with diverse cultural backgrounds.

Deep et al. (2023) offers practical guidance to enhance collaboration, including adjusting power dynamics, providing incentives such as bonuses or training opportunities, leveraging partnership expertise, ensuring effective communication, and implementing transparent procurement processes. These practices play a significant role in strengthening trust, commitment, and reliability, thereby contributing to the overall success of projects. PBOs must take into account these factors of relationship management, both when hiring and when being contracted, in order to establish and uphold effective partnership relations.

To address this challenge Jiménez-Barrionuevo et al. (2011) have developed a measurement instrument for AC that consists of intangible items reflecting the four phases of Zahra and George's (2002) framework. For the acquisition and assimilation phases, the identified items include: interaction, trust, respect, friendship, reciprocity, common language, complementarity, similarity, and compatibility. Therefore, according to this study, the value assigned to these items can determine the level of AC developed within the relationship between a firm and its partner company. This highlights the significance of the inter-organizational relationship for AC development. But, in cases where AC is contingent on the execution of PBO projects rather than solely dependent on the relationship between two companies, other factors may act as stimulators of AC, for example, complex solutions, strategic clients, and strategic projects. Executing challenging projects aligned with the company's strategy stimulates learning and innovation (Vicente-Oliva et al., 2015).

2.5. Activation triggers of absorptive capacity

Although AC plays a key role in helping PBOs enhance their knowledge, improve project performance, and gain a competitive advantage through innovation, the development of AC is not a natural process, and research examining the impact of AC on PBOs remains scarce (Eriksson, 2013; Escribano et al., 2009; Kanwal et al., 2019; Vicente-Oliva et al., 2015). Companies develop AC due to the influence of contingency factors that act as activation triggers, as suggested by Zahra and George (2002) and Todorova and Durisin (2007). However, while many studies have focused on the competitive benefits of AC as presented in Table 1, organizational antecedents and key contingencies such as activation triggers have been largely overlooked (Jansen et al., 2005; Todorova & Durisin, 2007).

Activation triggers refer to events that compel a firm to react to specific internal or external stimuli. These triggers are divided into internal and external categories. Internal triggers can emerge from organizational crises, such as performance failures, like a poorly managed project of significance, generating numerous considerations and lessons learned about what the PBO will and will not do (Villazón et al., 2020). Moreover, internal triggers may involve significant events that reshape a firm's strategy, such as deciding to enter a new market segment or establishing a strategic foreign partnership. On the other hand, external triggers include events that can influence the future of the industry in which the firm operates. These events encompass disruptive innovations, technological shifts, macroeconomic factors, and changes in government policies, among others. For instance, the emergence of electric cars necessitates strategic shifts for companies manufacturing components for combustion engines. Fluctuations in commodity prices can have profound impacts on investments in basic industries. Government regulations can reshape industry. For example, the serialization of medications introduces new systems and specialized machinery into production lines. PBOs operating within these markets must remain vigilant to sense, seize, and reconfigure in response to these external triggers (Fosfuri & Tribó, 2008; Teece, 2007; Zahra & George, 2002).

Therefore, the objective of this article is to explore the activation triggers that have stimulated AC in PBOs (Zahra & George, 2002), thus addressing the central question: "What triggers the absorptive capacity in PBOs?" While exploring these activation triggers, the article uncovers the knowledge sources accelerating AC and examines the relationship factors responsible for ensuring AC.

3. Methodology

In line with our aim to explore the activation triggers that stimulate AC within PBOs, we conducted an in-depth single case study, based on retrospective research. Cases studied retrospectively are based on interviews (and archival data) to effectively increase the quantity and detail of the cases, thus allowing a researcher to engage with a broader range of informants and incorporate a larger selection of cases, here specifically, executed projects (Eisenhardt & Graebner, 2007; Voss et al., 2002). Single-case research typically facilitates the understanding of significant phenomena in unique or extreme contexts (Eisenhardt & Graebner, 2007). Retrospective research enables the collection and correlation of evidence over time, thereby revealing temporal patterns, causes, and shifts from continuity to change, and vice versa, aligning with the scope of our research (Pettigrew, 1990). In this context, Söderlund (2023) posits that embracing historical perspectives is pivotal for fostering innovation and reflexivity regarding the future. It is imperative to reflect on our past to navigate the future trajectory of project management effectively.

3.1. Case selection

As it is a single case study with a PBO, the choice was made to select a company involved in an environment of extreme technological change that could be transparently observed. Companies with this profile can be sources of critical incidents or significant events that had a transformative impact on the organization. Such events assist researchers in identifying turning points or facts that influence the company's trajectory (Pettigrew, 1990). At the same time, as the study would be conducted in a PBO and given that the projects are the unit of analysis it was important to select a company with extensive project experience, ensuring that the sample was significant (Pettigrew, 1990; Voss et al., 2002).

Then, the single case study presented in this paper, which focused on a PBO, was selected due to its revelatory nature and longitudinal significance. The case called SPI, operating as a control system integrator (CSI) in Brazil. CSIs are specialized PBOs that provide industrial automation solutions by integrating hardware and software, catering to the industrial market's needs in implementing Industry 4.0 enabling technologies. CSIs operate across various industrial sectors, including automotive, chemical, pharmaceutical, food, oil and gas, mining, and metal industries (Barbosa et al., 2019). This type of PBO operates in a context of rapid technological advancements, making it an ideal setting to investigate the development of AC and comprehensively identify the triggers that activate it.

SPI started its operation 32 years ago and currently has 205 employees with offices in the states of São Paulo and Rio Grande do Sul, being considered one of the five largest CSIs in the country. The company has its operation divided in 3 business units (BU): Automation Technology, Robot Technology and Digital Technology. In the last 5 years the company delivered >400 projects with a turnover of >429 million reais (90 million dollars). SPI is a solution partner of two of the most well-known brands in automation today: Rockwell Automation and Siemens. In November 2022, SPI was announced as one of nineteen platinum solution partners of Rockwell Automation worldwide, considered the highest acknowledgment for CSIs associated with this renowned automation brand. This recognition is related to the level of capabilities SPI has developed in Rockwell solutions. Globally, there are 4034 Rockwell Automation partners. The other platinum solution partners are located in Chile (1), Mexico (2), USA (7), Nigeria (1), the Emirates (1), Australia (1), India (2), China (2), and Taiwan (1).

3.2. Data collection

This study employed a comprehensive approach, following the logical sequence of planning, collecting, and analyzing data. We had access to senior management and gained a deep understanding of the most appropriate sources of information, the company's history, and its internal and external environment.

Case studies provide in-depth empirical descriptions of specific aspects of a phenomenon, typically utilizing various data sources (Yin, 1994). Over a 30-month research span (2021–2023), we engaged with the company's senior management to identify fundamental projects central to the company's knowledge development and their key informants (Pettigrew, 1990). Subsequent interviews with these participants revealed detailed insights into these critical projects. This detailed, time-spanning projects data was imperative as the triggers of AC are influenced and evolve over time, shaped by the company's contextual environment (Lane et al., 2006). The access to data across a substantial period, from 1997 to 2022, was significant for this comprehensive retrospective analysis, aligning with Yin (1994) recommendations.

The data collection involved conducting semi-structured interviews while reviewing archival data related to the project epochs and their impacts on the company. We interviewed fourteen experienced engineers who have been employed by the company for over 10 years, spanning various levels such as Project Manager (PM), Sales Director (SD), Innovation Director (ID), Unit Manager (UM), Engineering Manager (EM), Solution Architecture (SA). The senior management determined who the fourteen respondents would be: those with the most knowledge about the topics to be researched. These individuals actively participated in the identified project epochs. Table 2 presents the interviewees profiles.

Building on the approach of Takey and Carvalho (2015), we sought to uncover the personal competencies cultivated by respondents through their involvement in project execution, underlining their importance to the organization. Simultaneously, the study by Jiménez-Barrionuevo et al. (2011) guided us in assessing the levels of relationships with partners. This foundation led to the development of the questionnaire presented in Appendix B. Thus, throughout the interviews, we specifically aimed to identify projects that held historical significance for the company, as they were responsible for notable changes in project management practices and contributed to the company's unique knowledge expansion. These projects represent crucial milestones in the organization's evolution. By mapping these projects on a timeline, we sought to understand the company's skill development trajectory and the activation triggers that played a pivotal role in the development of AC associated with each project.

The chosen projects should fulfill the established criteria: (i) projects whose solution was explored for a period of at least 5 years as lineage of projects (Kock & Germuenden, 2019; Salunke et al., 2019), (ii) vanguard projects that used state-of-the-art technology that raised the company's technical and commercial visibility and added a new solution to its portfolio (Davies & Brady, 2016), (iii) international partnership projects (Bakker, 2016), and (iv) projects that opened up opportunities in a new

Table 2
Profile of interviewees.

Interviewee sequence	Role in the company	Experience (Years)	Interviewee code
01	Project Manager	23	PM3
02	Solution Architecture	35	SA1
03	Innovation Director	32	ID1
04	Sales Manager	23	SM1
05	Unit Manager	25	UM1
06	Solution Architecture	35	SA2
07	Sales Director	18	SD2
08	Unit Manager	10	UM2
09	Sales Director	16	SD1
10	Project Manager	15	PM2
11	Unit Manager	15	UM3
12	Project Manager	10	PM1
13	Unit Manager	12	UM4
14	Engineering Manager	20	EM1

segment (Salunke et al., 2019). Consequently, the empirical work was divided into nine distinct phases to ensure a systematic and rigorous investigation as shown in Fig. 1.

During the interviews, which lasted between 55 and 73 min each, we collected information spanning the period from 1997 to 2022. As a result, the interviewees provided a list of 72 projects.

3.3. Data analysis

To understand the company's capabilities development and the activation triggers associated with each project, we first traced a timeline that highlighted these significant projects. Among the fourteen interviewees, we selected the four most senior individuals who were currently active in the business area (ID1, SD2, UM1, SM1). They held a key position in defining the criteria used for project selection and identifying project epochs that were instrumental in the company's capability building (Davies & Brady, 2016). To identify project epochs, they aimed to discern a pattern of dominant technologies and solutions that marked the progression of project activities throughout the company's timeline.

After analyzing all 72 projects and following these criteria, we removed 14 projects from the selection. There were 58 projects remaining. Upon reviewing this new selection, we identified 4 pairs of identical projects with identical triggers. We removed four from them, leaving us with a sample of 54 projects. It is interesting to note that in some cases, the same projects mentioned by the interviewees had different perspectives regarding the identified triggers, and thus they remained in the sample. The 54 projects and respective data are presented in Appendix A.

During the data analysis, we developed a coding book for empirical data (Gioia et al., 2013). We initiated this process by employing descriptive coding on interviews, observations, and documents, inductively creating code labels. As we progressed in the coding process, we performed recoding, merged overlapping codes, and clustered the data. For clustering the triggers we applied the affinity diagram, which is a tool that organizes variables into their natural relationships (Plain, 2007). The process typically involves the following steps: identification and listing of ideas (gathered triggers), sorting and grouping of ideas, categorizing these ideas into related groups or themes, creating header cards, and constructing the affinity diagram. We invited four participants (PM3, SA1, UM2, PM2) to engage in the group dynamic facilitated by the affinity diagram tool. These participants were selected due to their extensive technical involvement spanning the entire 25-year range of the retrospective research. This selection criterion aimed to ensure that the chosen experts possessed comprehensive insight and experience relevant to the projects under examination. Then we concluded the process after creating the header cards. This phase of the research provided us with an overview of the triggers, their groupings, and their relevance to specific themes (see Appendix A). Finally, to provide a detailed understanding of the interactions between activation triggers and the found sources of AC, the collected data were organized into a matrix. This helps identify which triggers are most relevant in promoting AC within a PBO.

The emergent codes were constantly compared with relevant literature constructs, especially those related to AC (Cohen & Levinthal, 1990; Kanwal et al., 2019), activation triggers (Fosfuri & Tribó, 2008; Zahra & George, 2002), and relationships factors (Jiménez-Barrionuevo et al., 2011). Subsequently, we engaged in axial coding to explore the relationships between first-order codes, aiming to obtain second-order themes and refine emerging themes. This step suggested aggregate dimensions that could aid in describing and explaining the observed phenomena (Gioia et al., 2013). Fig. 2 provides a summary of the coding

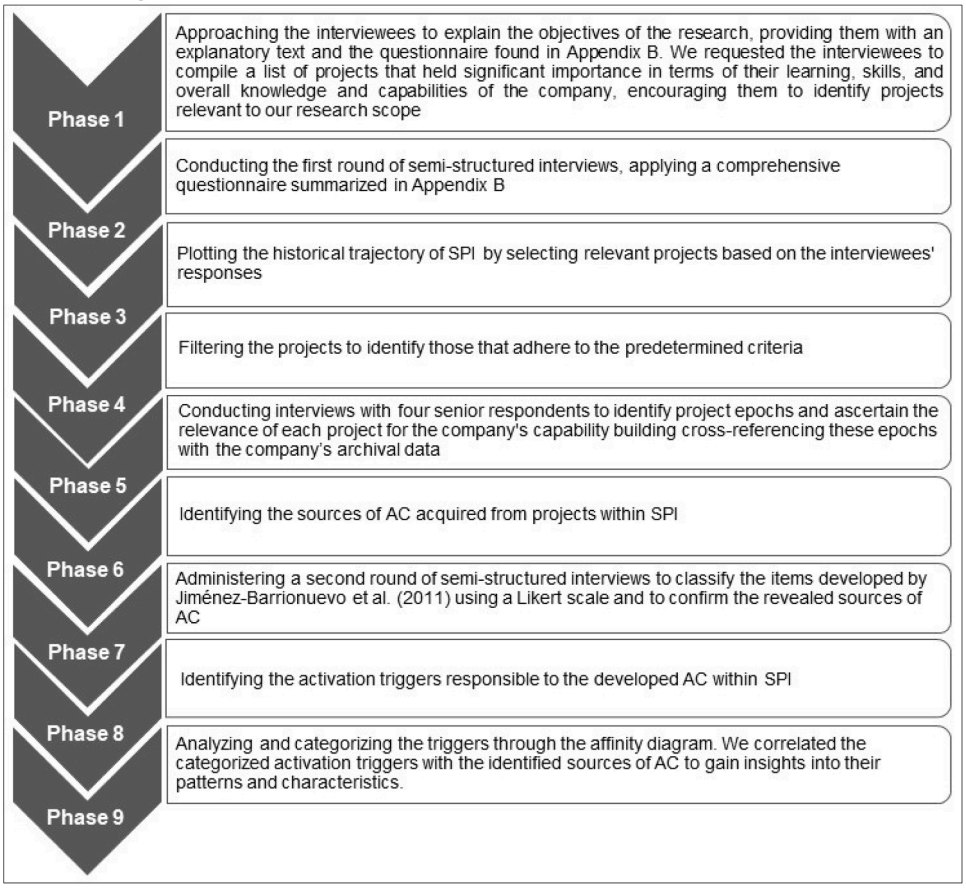

Fig. 1. Research phases.

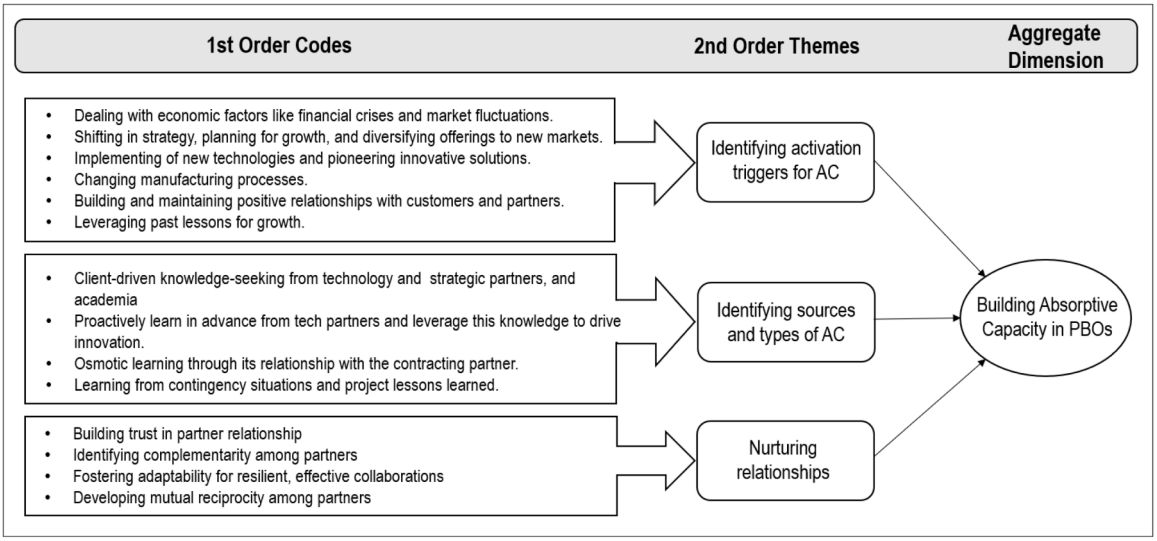

Fig. 2. Research coding structure.

structure.

This iterative process culminated in the development of a new theoretical framework for understanding ACs, triggers, and relationships, as depicted in Fig. 8.

4. Results and analyses

4.1. Project epochs

In phase 5, the four senior respondents carefully analyzed all the listed projects and identified the company's project epochs. Table 3 outlines the seven identified project epochs. Notably, the exploratory project (Kock & Germuenden, 2019) served as a significant milestone, marking the beginning of an epoch.

Based on these exploratory projects conducted throughout the company's history, subsequent projects were undertaken leveraging the knowledge and experience gained. Out of the total, 54 projects were identified to have direct alignment with the solutions, learnings, or technologies developed within these seven project epochs. Fig. 3 presents a chronological sequence of these project epochs.

While collaborating with senior managers to identify the seven project epochs, we utilized our access to the company's archives to correlate each epoch with relevant data, including revenue, service types, exports, and client portfolio expansion. This allowed us to investigate how these epochs, initiated by exploratory projects, significantly influenced the company's performance and the development of knowledge and capabilities. Table 4 presents key findings regarding these impacts.

4.2. Sources of AC acquired from projects and relationships

During the interviews, we identified that the AC acquired from the projects could be categorized into four sources: client relationships, technology partner relationships, strategic business-partner relationships, and the learning obtained through project execution in response to contingencies. Fig. 4 presents excerpts from the interviews that served as the foundation for us to identify these four types of knowledge sources and their connection with triggers.

After extracting these AC sources from the analysis of the interviews (phase 6), we used the second round of interviews (phase 7) to confirm the identification of these sources and to better understand the sequence in which they occur in the relationship with these sources. As a result, we classified these relationships as follows:

AC1-client: This type occurs when the PBO engages with clients and identifies a market need. The company recognizes the necessity of acquiring new knowledge to maintain or enhance its position in the market. The activation trigger is prompted by the company's need to expand its knowledge repository. In this case, the search for new knowledge is active, and AC is of the push type. The PBO actively seeks out knowledge from technology partners, strategic business partners, alliances, and academia, but the relationship is coordinated with the client.

The interviewee SD2 clarified that in AC1-client, although the knowledge gap must be filled by an organization that is the source of this knowledge, the customer accompanies this entire process because, in addition to being the demander of this new knowledge, he is also the sponsor for its acquisition. Thus, the relationship with the customer in this case is more relevant than the relationship with a technology partner, for example. For this reason, during the second round of interviews, the items of behavior between companies, in AC1-client, refer to the client-PBO relationship.

AC2-technology partner: This type emerges from the PBO's keen interest in advancing its technological capabilities. The company takes proactive steps to learn in advance and leverage this knowledge to drive innovation. The activation trigger occurs when a technology shift is identified, prompting the company to expand its knowledge repository. Like This type of source is also push-oriented, with the PBO actively seeking knowledge from technology partners, prioritizing these relationships in the process.

AC3-strategic business partner: This type occurs due to the PBO's exposure and involvement with its strategic business partners. The company is motivated to seek partnerships to either maintain or improve its market position. The activation trigger occurs when the company realizes that the relationship developed with the strategic business partners can be expanded to increase its scope of supply in future opportunities. Distinct from the prior types, Strategic business partner source AC is pull-oriented, with the PBO primarily learning through its relationship with the contracting partner, often under their guidance. Although the knowledge garnered in this relationship may not always be directed by the partner, it's imperative for the PBO to seize the learning opportunities presented, as evidenced in this case study.

Regarding the strong relationship SPI has with partners, interviewee ID1 said: "When challenged or voluntarily initiating the search for new capabilities, SPI regularly practices exploring partnerships with giants before starting a journey in isolation, be they universities, science and technology institutes, technological partners, clients or specialists to

Table 3
Project epochs found.

BU Epoch	Project Epoch	Exploratory Project	Description of the Scope
Automation Technology 1996–2003	Automation Projects in the process industry.	APC reactors and mills automation	Automation based on process control involves the use of flow, temperature, and pressure loops, as well as dosing and transfer control.
Automation Technology 2009–2014	Automation projects following new AAC standard	AAC Alive Project-Argentina	A new automation system has been implemented specifically for body shop applications across AAC plants worldwide.
Robot Technology 2003–2006	Turnkey projects for AAC Body Shop area	AAC 4300 and PoBox JWC and JCC Project.	The beginning of two significant international partnerships with JWC and JCC, fundamental for SPI's development in managing turnkey projects.
Robot Technology 2006–2009	Robot Cells Projects	JAC Door Sachi Project	Formed a strategic partnership with JRC, a leading robot manufacturer, delivering two weld robot cells to JAC, gaining valuable insights and expertise in designing such projects.
Digital Technology 2003–2006	Vertical Integration SCADA MES ERP	APC Industrial coating Project	Integration with a pioneering ERP system transformed requirements into streamlined processes. A middle layer of traceability and a custom MES system were implemented, enhancing automation team knowledge and project management, decisive for the initiatives' success.
Digital Technology 2014–2016	Digital Simulation Projects	BMCs Laboratory Simulation	Providing consultancy services for the comprehensive robotization of BMC's laboratory, the project involved expertise in developing a master plan and executing simulations of future scenarios using the GAC simulation platform.
Digital Technology 2016–2023	Traceability Cloud Projects	BPC serialization and traceability project	The company underwent a mindset change, adopting the Software as a Service (SAAS) model and moving operations to the cloud, facilitated by a strategic partnership with ATC, essential in shaping the new business model.

Note: APC (American Painting Company), AAC (American Automaker Company), JAC (Japanese Automaker Company), JWC (Japanese Welding Company), JCC (Japanese Conveyor Company), BMC (Brazilian Mining Company), BPC (Brazilian Pharmaceutical Company), ATC (American Traceability Company), JRC (Japanese Robot Company), GAC (German Automation Company), MES (Manufacturing Execution System), ERP (Enterprise Resource Planning).

speed up the process."

AC4-project execution: This type arises from the execution of the project portfolio. The company learns by encountering contingency situations that projects demand. The activation trigger occurs when the company identifies a knowledge gap during project execution and subsequently develops the required knowledge through partnerships. In this case, the PBO learns through lessons learned and knowledge management in its project-related interactions. AC4-project execution is also push-oriented. Fig. 5 illustrates these sources of AC encountered and their flow.

For both AC1-client and AC2-technology partner, addressing the knowledge gap primarily involves the project team itself and direct interaction with partners. Subsequently, for future projects, this newfound knowledge should be mobilized throughout the entire project team within the PBO. This can be achieved through internal training sessions involving team members who acquired the knowledge or through external collaborations with relevant partners, particularly technology partners or universities. In contrast, when the knowledge gap is filled by a strategic business partner, knowledge dissemination is typically facilitated internally within the PBO by those who acquired it. Strategic business partners often share knowledge through hands-on experience. Similarly, in the case of AC4-project execution, knowledge acquired during project execution resides within the project team. Successful knowledge transfer hinges on the PBO implementing effective knowledge management mechanisms to overcome known barriers (Duffield & Whitty, 2016; McClory et al., 2017).

Certainly, effective financial management is essential to balance the costs and benefits of AC. While AC can bring significant advantages in terms of innovation and financial performance, careful planning is necessary to avoid high costs and potential long-term negative effects. Strategic investment in AC can maximize financial returns and ensure the sustainability of the competitive advantages obtained (Lichtenthaler, 2016). However, this specific type of analysis is not within the scope of this study.

In phase 5 of our methodology, interviewees also examined the existing levels of relationships between the company and three entities: its clients, its technology partners, and its strategic business partners . Through this process, we discovered significant variations in the company's relationships with these different entities.

During these discussions, the interviewees considered several factors from a study by Jiménez-Barrionuevo et al. (2011). These factors of relationship included interaction, trust, respect, friendship, reciprocity, common language, complementarity, similarity, and compatibility. Yet, when asked if there were any other factors that were relevant in these relationships, the interviewees introduced an additional factor to the set, adaptability, which refers to a flexible and humble attitude towards cultural differences, standards, methods, and technologies when dealing with clients and business partners. Therefore, we decided to explore this factor as well. According to the interviewee SM1, this flexibility greatly enhanced knowledge absorption, avoiding a counterproductive "my way is better" mindset. To exemplify he shared an experience where they had high hopes for a client's visit to review an ongoing project. Unfortunately, the client found the project's quality lacking and remarked that a similar project by a competitor was superior. "The client escorted us to the competitor's office to see their approach firsthand. It was an unprecedented experience — learning directly from a competitor under our client's guidance. We had to accept the client's directions, demonstrating flexibility" (Appendix A - Project Index 4).

Based on our data, we observed a clear hierarchy of importance for each type of relationship. Trust consistently emerged as the primary factor in customer and technology partner relationships. Nonetheless, in the case of strategic partnerships, trust ranked second in importance. This is attributed to the fact that these partnerships often involve foreign entities, necessitating a higher degree of adaptability to accommodate cultural differences and working methods, as reported by the respondents. Adaptability also played a significant role in customer

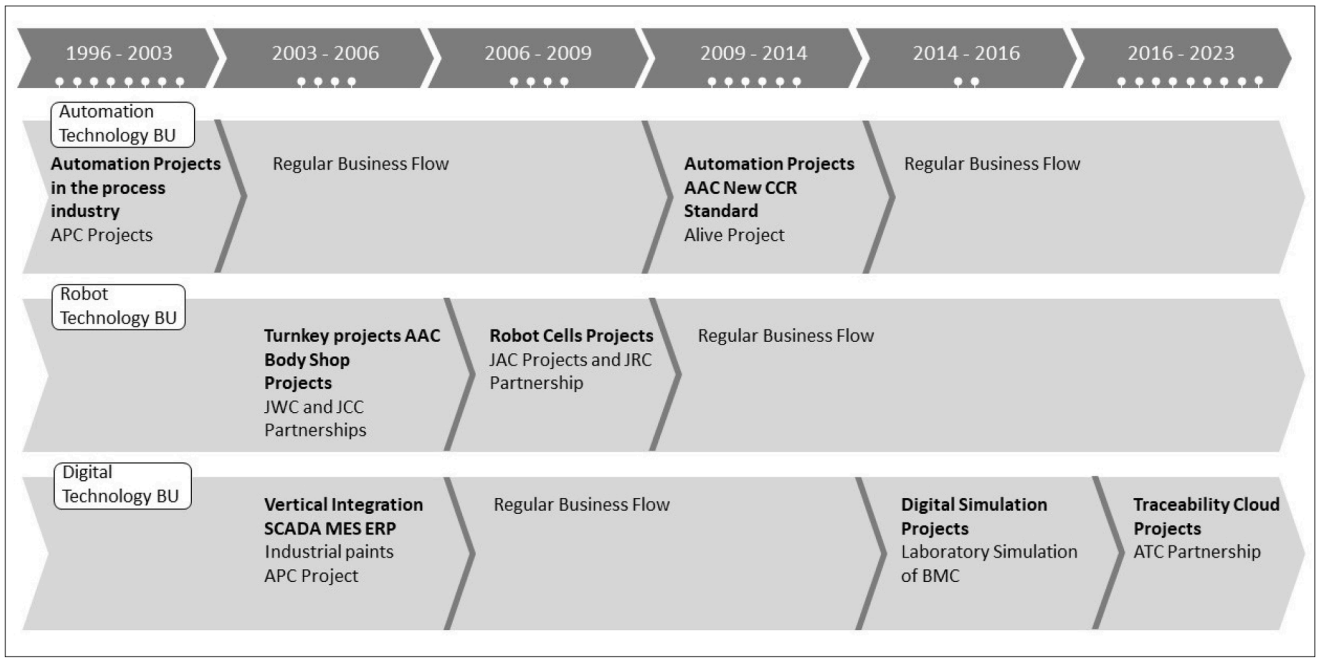

Fig. 3. General overview of defined project epochs.

relationships, securing the second position. This adaptability stems from the nature of PBO's work, which involves developing projects based on customer demands, often requiring innovative solutions. Additionally, respect was identified as a prominent factor across all types of relationships. Other factors, such as common language, similarity, and compatibility, were seen as less important.

As we shifted our focus to the company's relationship with its projects (AC4-project execution), it became evident that these factors were not suitable, as the relationships here were not personal. During phase 7, interviewees were asked to identify the factors that most stimulate the company's AC in project management execution. According to them, these factors involve working on strategic projects (projects aligned with the company's strategic focus), strategic clients (clients listed as relevant business accounts), new clients (new accounts for the company), new technology (cutting-edge technology not previously worked on), and complex projects (solutions involving multiple interfaces and stakeholders). Once again, we identified a hierarchy of importance for these stimulating factors.

As mentioned in Phase 7, the respondents used the Likert scale to rate the importance of each of these relational factors between the PBO and the sources of AC, as well as the factors that stimulate learning in projects when the source was AC4 - project execution. The percentages presented in Fig. 6 are the result of the respondents' ratings, grouped by AC source. The hierarchy presented shows small differences between each of the factors, because in the instrument of Jiménez-Barrionuevo et al. (2011), these factors are all important for the development of AC. Nevertheless, these small percentage differences defined hierarchical changes compatible with the relationship between the source of AC and the PBO.

The charts in Fig. 6 display the relational factors and their importance for each source of AC. They also present the level of importance of stimulators of AC in project execution.

In this regard for example, interviewee PM1 considered that the activation trigger for the Appendix A - Project Index 30 was the fascination with the complexity, technology and process employed. According to him, there are several projects in which the company learns because its professionals "fall in love with what they are going to use as a solution in the project".

4.3. Activation triggers and relationships with types of AC

The main objective of this article was to explore activation triggers and gain a deeper understanding of their context. To achieve this, in phase 9 we conducted interviews with participants who shared details about their projects and the associated learning experiences. These interviews were then analyzed, and the data was compiled into the table presented in Appendix A. The table provides information about the project owners, project names, triggers, and types of activation triggers. It is essential to highlight that detailed project descriptions and specific learning outcomes have been omitted from this table due to confidentiality considerations and their limited direct relevance to this study. Using the affinity diagram method, the four participants were able to condense the triggers into six distinct categories, as outlined below and Table 5 presents a summary of the categorized of activation triggers (ATs):

Economic conditions and competitiveness (AT1): This category encompasses triggers related to economic conditions and the need to maintain competitiveness in challenging market environments. Triggers in this category highlight SPI's response to financial crises, market fluctuations, and the importance of forming alliances to expand its position. SPI navigates through a crisis in the automotive sector, seeks opportunities in new markets, and capitalizes on favorable exchange rates for exportation.

Business strategy and expansion (AT2): This category focuses on triggers related to strategic changes, growth plans, and diversification of SPI's business. Triggers here demonstrate SPI's initiatives to expand its knowledge, operate in different industries such as oil and gas, pharmaceuticals, and agribusiness, and seek partnerships to enhance its market presence. SPI adapts its strategy, leverages government regulations, and explores new business opportunities to achieve growth.

Innovations and new technologies (AT3): This category encompasses triggers related to the adoption of innovative technologies and the utilization of cutting-edge processes. Its triggers highlight SPI's involvement in projects that require the integration of new technologies, such as process automation, IT advancements, and the mastery of cutting-edge tools. SPI capitalizes on the need for plant modernization, stays at the forefront of technological advancements, and ensures its technical skills align with the latest industry trends.

Table 4
Project epochs cross-referencing to company's archival data.

BU Epoch	Data extracted from company's managerial reports	New Knowledge & Capability
Automation Technology 1996–2003	Company expanded its scope, venturing into batch processes, mining, and oil and gas sectors. The clientele grew from about 22 to 243 accounts.	Control strategy for new segments, improvements in standards for process industry
Automation Technology 2009–2014	Upon adopting the new AAC standard, the company's export value surged from 3.9 to 14.3 million Reais over a comparative period of five years before and after the change.	Novel algorithms and logics to build software and hardware architectures enhancing performance
Robot Technology 2003–2006	Interaction with these strategic business partners increased the rents from AAC from 69.9 to 114.1 million Reais over a comparative period of five years before and after the change through the completion of turnkey projects.	Design and construction of mechanical equipment, improvements in project management for turnkey
Robot Technology 2006–2009	New project types linked to new processes in various clients were introduced. Until 2005, SPI had integrated robots only in AAC projects. After partnering with JRC in 2006, 362 robots were integrated with 52 new clients.	Robot programming, robot cells design and construction for different types of application
Digital Technology 2003–2006	The unit began applying hybrid project applications connecting automation with the client's ERP, increasing the scope scale with the same clients (APC, AAC, BMC).	Implementation of the connection between shop floor data and the ERP, configuration of MES systems.
Digital Technology 2014–2016	The unit expanded partnerships and the scope base with the same clients and the partnership with GAC's digital simulation division began.	Methods of digital simulation, simulated try-outs, budgetary simulated process
Digital Technology 2016–2023	With this new project, the company started billing by subscription with recurring revenue in cloud-hosted projects. A total of 32 new cloud projects has been executed since 2021.	Cloud computing solutions, cloud hosting, cloud interfaces, traceability projects

Technological shifts and adaptation (AT4): This category focuses on triggers related to adapting to technological shifts and keeping pace with evolving market trends. Triggers inside this category demonstrate SPI's ability to adapt to changes in manufacturing processes, embrace robotization, and staying updated with emerging technologies like the Rockwell systems evolution. SPI proactively responds to shifts in the market by introducing innovative solutions and adapting its software offerings to meet client needs.

Partnerships and relationships (AT5): This category encompasses triggers related to building and maintaining strong partnerships and relationships. Triggers highlight the importance of client relations, partner recommendations, trust-building, and strategic partnerships in SPI's success. SPI leverages its reputation, expertise, and understanding of customer needs to forge strong relationships, gain client recommendations, and secure partnerships that open new business opportunities.

Project Experience and Learning (AT6): This category focuses on triggers related to project experience, learning, and continuous improvement. Triggers in project experience and learning highlight SPI's emphasis on leveraging past project experiences, adapting to the latest technological advancements, and continuously improving its performance. SPI's commitment to learning from previous projects, maintaining a strong project management approach, and analyzing lessons learned drives its ability to deliver high-quality results.

In Phase 9, we also explored the main relationships among activation triggers and the sources of AC by creating a matrix, as depicted in Fig. 7.

Each cell in the matrix contains the count of occurrences of each activation trigger associated with a specific source of AC, and the percentages reflect the distribution of these associations. The results shed light on the various activation triggers associated to AC within projects. One notable finding is the significant emphasis on AT5-partnerships and relationships across all sources of AC (28 %). AC3-strategic business partner particularly align with the AT5-partnerships and relationship, highlighting the critical role of collaborative relationships for PBOs. AT2-Business strategy and expansion also emerges as a pivotal factor (20 %), especially concerning AC1-client and AC4-project execution, emphasizing the importance of aligning business strategies with clients to plan the PBO's expansion into new segments.

Moreover, the study reveals the importance of AT3-innovations and technology, accounting for 17 % of the triggers, particularly relevant to AC4-project execution, underscoring the necessity for PBOs to adapt and integrate new technologies to remain competitive through technological innovation in project execution. Additionally, the findings indicate that AT6-project experience and learning has a greater association with AC2-technology partners and AC4-project execution than on other ACs. This suggests that continuous learning from project experiences can be a valuable source of knowledge acquisition for PBOs and their technology partners. Other activation triggers occurred less frequently.

5. Discussion

5.1. What triggers AC and the framework

The research question raised in this study: "What triggers the absorptive capacity in PBOs?" was answered through Table 5, and the framework of Fig. 8 elucidates the relationships that must be established and preserved by the PBO to support AC activated by these triggers (Deep et al., 2021; Jiménez-Barrionuevo et al., 2011). These triggers will only be effective in the PBO if it stays ahead by keeping up with changes in its external environment and closely monitoring internal decisions aimed at maintaining its competitiveness.

The activation triggers identified in this article expand upon the studies of Zahra and George (2002) and Todorova and Durisin (2007) by being categorized and exemplified through the case study. The six categories of activation triggers are related to economic fluctuations and crises, strategic decisions for growth, process innovation, technological solutions, and the trust developed with clients and partners. Additionally, the PBOs face the challenge of developing AC by extracting knowledge from the solutions applied in projects, knowing that project execution, as shown in Fig. 7, is its main source of knowledge (Duffield & Whitty, 2016; McClory et al., 2017).

Our study introduces a novel theoretical framework for developing AC in PBOs. Key relationships with technology and strategic business partners are crucial, as these partnerships help PBOs develop AC during high-pressure times. Four components were vital for the development of the framework presented in Fig. 8: the six categories of activation triggers (Table 5), the four sources of AC (Fig. 5), the ten relational factors between the PBOs and its clients, technology partners, and strategic business partners and the five factors that most stimulate AC in project management execution (Fig. 6). As they operate in an environment of constant technological changes, either derived from their own solutions or the demands of their clients and business partners, PBOs need to

Trigger	Trigger Category	Interviewee	Quotations
Client opportunity revealed important technology for SPI to learn.	Innovations and Technology	UM1	"We learned a new technology pushed by the client"
Client felt pressured to improve process performance.	Technological Shifts and Adaptation	PM2	"The client had previously studied a lot on how to improve the process through control algorithms"
New client with potential but surrounded by commercial risks.	Economic Conditions and Competitiveness	UM2	"Learning a new standard with the client enabled us for other businesses"
Good relationship with client from previous small projects positioned SPI favorably.	Business Strategy and Expansion	UM2	"The technology was new and surrounded by many risks, but the client's support was crucial for everything to work well"
JRC partner's position change prompted SPI's strategy shift to develop robotic cells.	Business Strategy and Expansion	SA1	"JRC taught us a lot about robotization"
Consolidation of new technology for economic viability and expansion in the chemical industry.	Project Experience and Learning	PM1	"The technology was the partner's domain, but we were very familiar with the process"
Government regulation prompted need for a global partner in the pharmaceutical industry.	Partnerships and Relationships	ID1	"Before reinventing the wheel, we look abroad for a partner with the necessary knowledge"
Traceability law seen as an opportunity to enter the pharmaceutical market and gain scale.	Business Strategy and Expansion	UM2	"It was with ATC that we learned how to work on a cloud platform"
Relationship with client, experience in automation. Client recommended SPI to a japanese welding company.	Partnerships and Relationships	SA1	"It was the first time we worked with JWC. We learned a lot from their methods and culture"
Strong relationships with business partners and clients, preparedness, and understanding of the ecosystem.	Partnerships and Relationships	SA1	"JCC was very organized and elevated our approach to handling larger projects"
Exposure to well-managed projects by Fuji and expertise in software and communication.	Partnerships and Relationships	EM1	"JWC's project and people management made a difference for us"
Partnership with ASC sought to boost business as a service area partner.	Business Strategy and Expansion	UM1	"The methodology was defined by the partner and very well accepted by the client"
Client compared SPI's work to a competitor's, leading to improvements.	Partnerships and Relationships	SM1	"The client was bold in asking us to familiarize ourselves with the competitor's standard. This project took us to another level"
Financial crisis compelled SPI to take on a unique project in the automotive sector.	Economic Conditions and	SA1	"Although it was a risky project, there was a crisis in the market that forced us to take it on"
Cutting-edge system utilizing new technologies in process, IT, and automation.	Innovations and Technology	UM2	"Everything was new to me, especially the technology. The project taught me a lot"
Challenging project where trust and partnership with the client were crucial.	Partnerships and Relationships	PM2	"The project's criticality led us to thoroughly study the process, mitigating risks"

Fig. 4. AC Sources identification and triggers.

continuously expand and improve their knowledge by developing AC as a flow (Hermano & Martín-Cruz, 2020; Löwstedt et al., 2018). This flow is represented in the center of the framework.

The framework reveals that "Clients" are pivotal knowledge source for AT2-business strategy and expansion. For specific needs arising from AT6-project experiences and learning, technology partners are prone to fill the knowledge gaps. In economically uncertain times, AC3-strategic business partners emerge as key allies for the PBO to respond to AT5-partnerships and relationships. Lastly, the framework highlights that learning from AC4-project execution satisfies the AT3-innovations and technology requirement, illustrating a comprehensive approach to developing AC in PBOs.

The categorized activation triggers highlight the necessity for PBOs to be agile in responding to market shifts, which is crucial for both survival and seizing new business opportunities. This adaptability allows PBOs to form strategic alliances and strengthen their market positions (Kivilä et al., 2017; von Danwitz, 2018). In times of economic uncertainty, this agility enables PBOs to turn potential threats into competitive advantages by leveraging favorable economic trends, such as advantageous exchange rates, to boost export capabilities.

For PBOs, expansion and diversification ensure sustainability and resilience by broadening their knowledge base. This approach helps mitigate sector-specific downturns and maintain growth. Preparation is essential for managing projects in different locations with diverse stakeholders and clients, considering the specificities of new segments (Choi et al., 2018). Additionally, PBOs must be attentive to governmental initiatives and regulations that can create significant business opportunities. Collectively, these triggers prepare PBOs to not only navigate but also shape the evolving landscape of industry standards and meet changing client expectations.

5.2. *Insights from project epochs and partnerships*

The project epochs identified in this study confirmed that there were indeed periods during which the company developed similar technology projects resulting from its involvement and execution with complex and exploratory projects (Söderlund & Tell, 2009; Kock & Germuenden, 2019). During these periods, significant knowledge leaps occurred due to the development of AC. Furthermore, analyzing Fig. 3, we observe that the company was involved in simultaneous or immediately sequential project epochs across its three BUs. Consequently, the PBO developed AC from the four sources simultaneously.

The analysis of project epochs was conducted by aggregating all three BUs, but even if the company did not have such a division, as a PBO with a significant number of open projects in its portfolio, it is natural for AC to occur simultaneously, stimulated by the identified triggers. This simultaneity of AC demands a highly aligned interaction between the PBO and its AC sources, with due consideration of the

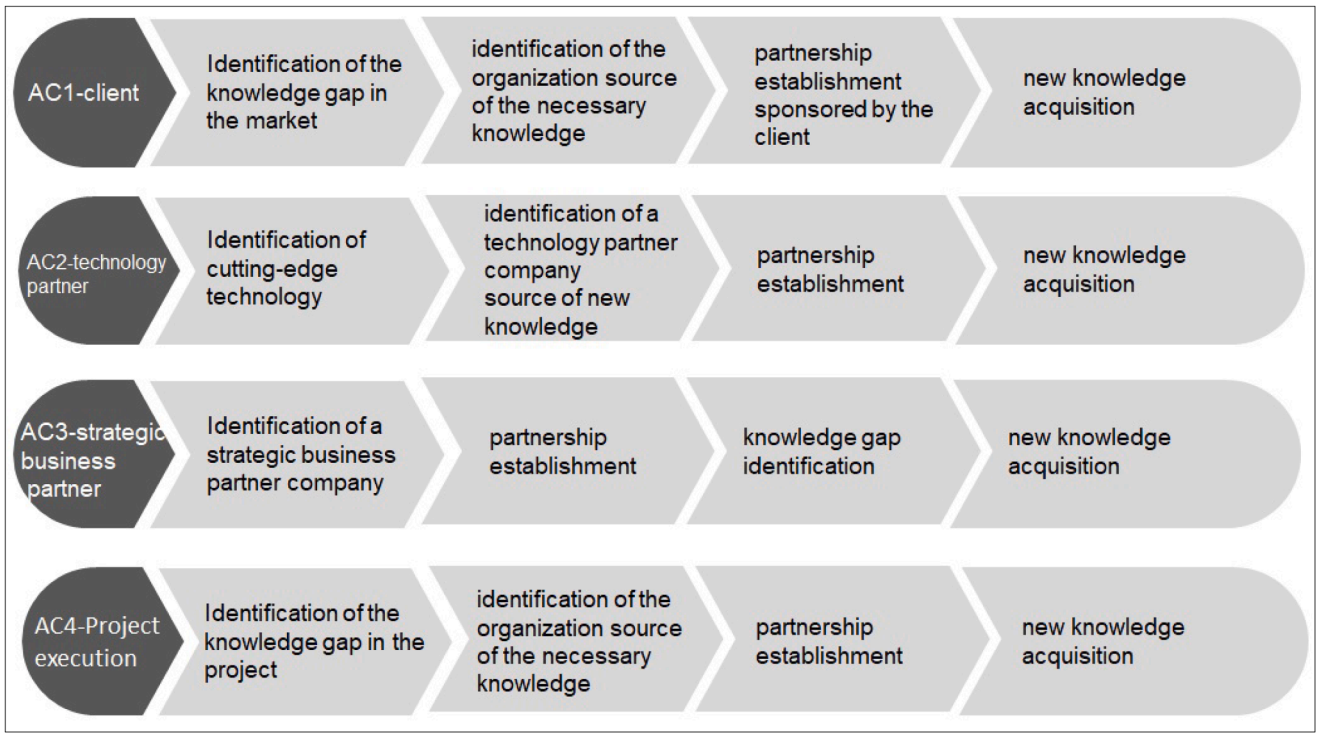

Fig. 5. Flow types of AC in PBOs.

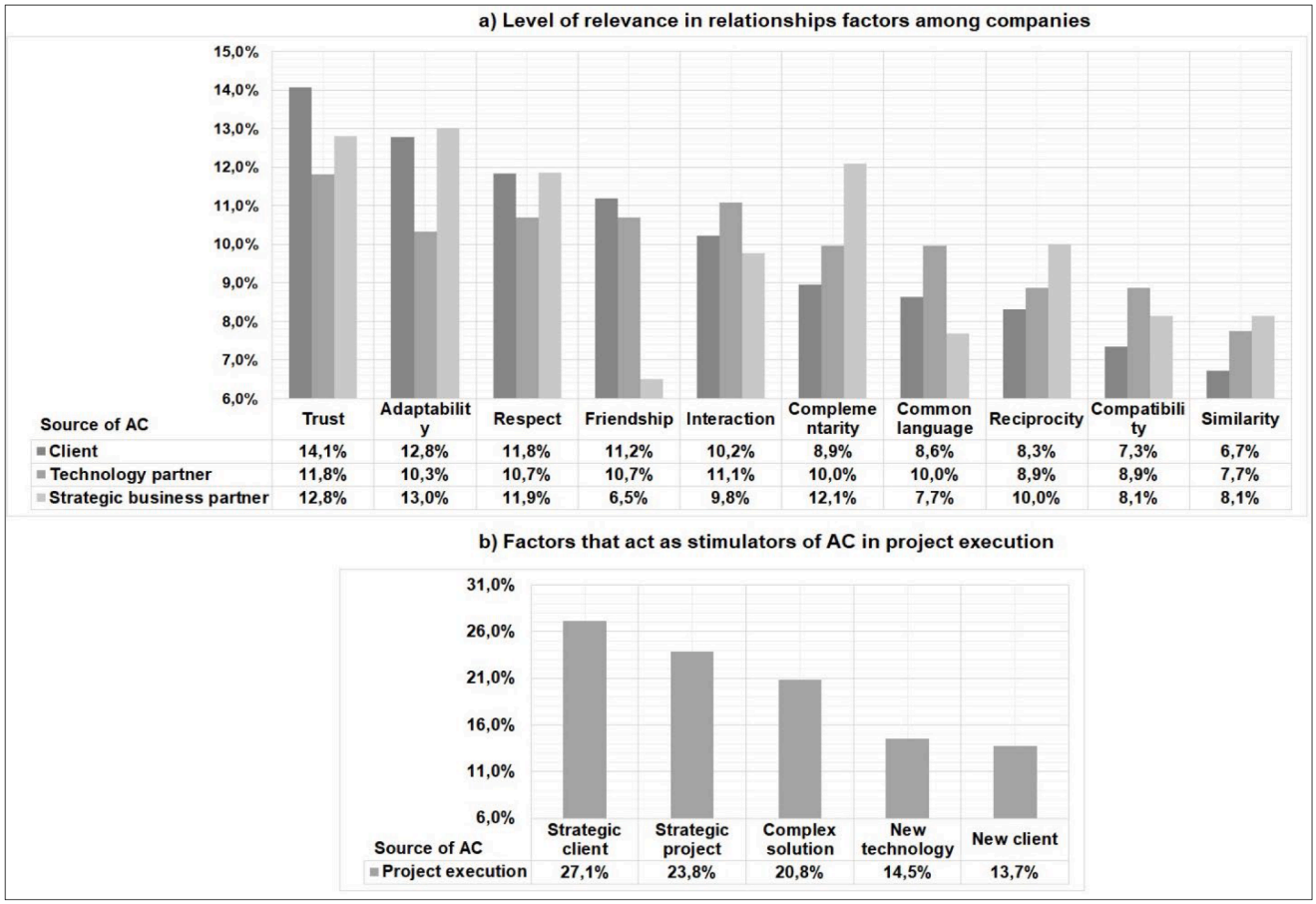

Fig. 6. Factors of relationship between PBO and sources of AC.

Table 5
Summary of found triggers and categories.

Code	Category	Key Themes	Summary	Trigger Index
AT1	**Economic Conditions & Competitiveness**	Financial crisis, economic changes, market shifts	Dealing with economic factors like financial crises and market fluctuations to maintain competitiveness.	2, 11, 20, 22, 34
AT2	**Business Strategy & Expansion**	Strategy changes, growth plans, diversification	Involves shifts in strategy, planning for growth, and diversifying offerings to explore new markets or sectors.	5, 14, 16, 23, 26, 38, 41, 43, 50, 53, 54
AT3	**Innovations & Technology**	Pioneering technologies, innovation in process/IT/ automation	Refers to adoption and implementation of new technologies, pioneering innovative solutions, and updating technical skills.	1, 9, 13, 17, 25, 30, 45, 46, 51
AT4	**Technological Shifts & Adaptation**	Shifts in manufacturing processes, technology changes in market	Involves the response to changes in manufacturing processes or other market tech trends, adapting to maintain relevance.	12, 15, 29, 35, 39, 40
AT5	**Partnerships & Relationships**	Customer relations, partner referrals, trust building	Focuses on building and maintaining positive relationships with customers and partners, impacting business success.	3, 4, 6, 7, 8, 18, 24, 27, 28, 31, 32, 33, 42, 44, 52
AT6	**Project Experience & Learning**	Quality concerns, past project experiences, stimulated learning	Captures the learning curve, past experiences, and quality improvements in project execution, leveraging past lessons for growth.	10, 19, 21, 36, 37, 47, 48, 49

relational factors mentioned in this study and explored in Fig. 6 (Deep et al., 2023; Jiménez-Barrionuevo et al., 2011).

Before starting the construction of an innovative project solution, it is important to understand if within the environment and the scenario involving the PBO, there is a company that already offers this solution, if there is a market leader, and if the PBO could establish a partnership with them to accelerate learning via AC, avoiding wasted time and resources and increasing competitiveness (Deep et al., 2023; Barbosa et al., 2019). Fig. 5 showed that the PBO should follow a flow to address a knowledge gap. This flow can lead to an appropriate alliance. By establishing an alliance with a partner, the PBO can become part of their network and offer services. This happened with the studied PBO at the beginning of three project epochs, as seen in Fig. 3 with partners JWC, JCC, JRC, and ATC.

This study highlighted the importance of a strategic business partner as a source of AC for the PBO. Major international partners supported the studied PBO in expanding its knowledge. Similarly, as PBOs are driven to develop AC in relationships with this type of partnership, they need to view their subcontractors with the intent of transferring knowledge, considering that they too can become strategic partners, collaborating with the competitiveness of the contracting PBO. In the dynamic project environment, PBOs that develop dynamic capabilities often stop performing certain services in their portfolio to focus on their core activities in the pursuit of competitiveness (Barbosa & Carvalho, 2019; Salunke et al., 2019).

Due to their uniqueness, projects frequently require new knowledge (Singh et al., 2023). When the PBO is executing projects within a project epoch, it may happen that they require only minor knowledge adjustments as they are derived from an exploratory project (Kock & Germuenden, 2019). However, when there is a shift from one epoch to another, there is a need for intense knowledge absorption to provide new solutions in projects whose complexity is related to this new epoch (Söderlund & Tell, 2009). Establishing partnerships and maintaining good relationships with AC sources are valuable.

5.3. Implications for practice

This study highlighted the importance of paying attention to the knowledge derived from strategic business partnerships, as evidenced in the spontaneous learning that takes place in these relationships. Therefore, the PBO must remain attuned to the partner's actions and astuteness which can enhance its AC. To maximize the innovation potential offered by AC, PBOs need to avoid the "my way is better" mindset, instead adopting a flexible approach with partners, listening more and speaking less to learn more. For example, SPI formed a partnership with a Japanese company (JWC) to capitalize on investment opportunities in the automotive market, which was being increasingly dominated by foreign suppliers (Appendix A - Project Index 2). In this case, cultural adaptation and flexibility were necessary. Over time, according to the interviewee ID1, "a win-win relationship was developed with JWC's managers, aiming for efficiency gains for both sides. As a result, JWC recommended us to JCC, and we have developed a long-term relationship, executing projects in Brazil, Mexico, Japan, USA, and Argentina."

Furthermore, given the significance of technological advancements in the development of dynamic capabilities and AC, PBOs internally should view technology providers not just as supply chain entities but as technology partners. This is how they have been identified in the framework. The case study demonstrated that such awareness and relationships generated new business opportunities and opened frontiers for the company under study. It is vital for PBOs to establish a collaborative environment with their business and technological partners, continuously fostering a win-win relationship so that trust, respect, and commitment consistently guide business interactions. Transparency, risk balance, and power dynamics should guide the management processes of these partnerships from procurement through to project completion. A long-lasting partnership between partners is one in which both parties see value in each other. This value should not be based solely on individuals but rather between the organizations themselves. This approach leads to knowledge generation through AC, innovation and project performance (Ali et al., 2018; Deep et al., 2021, 2023; Singh et al., 2023).

The clients proved to be an important source of innovation. It is through the clients that the company has valuable opportunities to innovate by understanding the market needs. The client serves as a rich source of knowledge for AC, and thus, the PBO should encourage an adaptable posture, a relationship built on trust and respect through their interaction with the client. This adaptability is further enhanced when the PBO engages in open and systematic discussions about opportunities for improvement, showing clients that their suggestions are valued and integrated into the PBO's daily operations. Furthermore, transparency and foresight by the project manager in client relations are essential for maintaining a productive and collaborative environment.

Projects proved to be an important source of knowledge for AC. However, there are challenges to ensure this happens effectively, and this issue needs to be on the agenda of PBOs (Love et al., 2016). PBOs

Sources of Absorptive Capacity / Activation Triggers	AC1-Client	AC2 - Technology Partners	AC3 - Strategic Business Partners	AC4 - Project Execution	All	%
AT1 - Economic Conditions and Competitivenes	1	0	2	2	5	9%
AT2 - Business Strategy and Expansion	4	2	2	3	11	20%
AT3 - Innovations and Technology	3	0	1	5	9	17%
AT4 - Technological Shifts and Adaptation	3	1	1	1	6	11%
AT5 - Partnerships and Relationships	3	2	6	4	15	28%
AT6 - Project Experience and Learning	0	3	1	4	8	15%
All	14	8	13	19	54	100%
%	26%	15%	24%	35%	100%	

Fig. 7. Relationship between activation triggers and sources of AC.

should take advantage of the learning opportunities presented during project execution, as illustrated in Fig. 6, with a particular emphasis on projects involving strategic clients, strategic projects, or even complex ones. This type of learning occurs through the challenges that professionals set for themselves, and as it is acquired tacitly, it needs to be disseminated. The PBO should establish robust mechanisms to safeguard knowledge derived from projects, ensuring that learning is captured and documented prior to project closure. Moreover, implementing micro-processes during project execution stages can facilitate the identification and preservation of valuable knowledge. It is also beneficial to integrate forums for sharing lessons learned into the company's practices (Duffield & Whitty, 2016; Moraes et al., 2020).

The study also emphasized the importance of the PBO seeking reference companies that are already involved in market trends. Partnerships or alliances with such companies can accelerate the PBO's competitiveness and growth if it develops AC through these collaborations. Before embarking on an initiative without the necessary knowledge, it is important to ascertain if another company has already made progress in that area. In evaluating potential alliances, it is essential to assess the alignment with the organization's strategic objectives, determining whether the partnership will complement existing competencies or facilitate entry into new markets. Furthermore, the cultural and operational compatibility between organizations must be examined, including an assessment of alignment in terms of values, work practices, and objectives. Lastly, the value of the knowledge to be shared between organizations should be determined, involving the identification of unique knowledge each partner brings and how these insights can be leveraged for mutual benefit (Jiménez-Barrionuevo et al., 2011).

6. Conclusions, limitations, and future studies

In conclusion, this article makes a substantial contribution to the existing body of knowledge by offering deep insights into the dynamics of AC development within PBOs, along with a detailed exploration of its antecedents, complementing previous studies in the field (Zahra & George, 2002; Todorova & Durisin, 2007). It clearly addresses the research question by elucidating what triggers AC in PBOs. It deepens the understanding of AC activation triggers and clarifies the main sources of AC in a PBO. A new theoretical framework was developed, advancing our comprehension of the mechanisms through which PBOs assimilate and leverage external knowledge through AC stimulated by activation triggers. The examination of these activation triggers provides significant theoretical contributions and practical implications for enhancing the field of project management. Exploring the practical application of AC within PBOs is crucial, as it enables these companies to strategically leverage AC to enhance operational efficiency and gain a competitive advantage in their respective industries..

It is essential to acknowledge that this research relied on a single case study of a specific PBO within the industrial automation projects context in Brazil. Consequently, the findings may have limited generalizability, and some aspects of the framework can be context and path-dependent. Additionally, being a retrospective case study, there are inherent limitations associated with participants' recollection of events and the potential for post-rationalization, which may lead to interpreting events differently from how they might have at the time (Voss et al., 2002).

Despite these limitations, several factors contribute to the rigor and validity of our study. These include the analysis of a substantial number of projects (54), the significance of these projects in expanding the company's capabilities, the selection of respondents for their seniority and ongoing active roles within the company, and the transparency of the methodology used. Additionally, the selected case involves a PBO with 32 years in the market, having formed various alliances throughout its history and executing a high volume of projects annually. Notably, our methodology involved the identification of project epochs according to respondents' views and triangulation with managerial records provided by the company through its management system, ensuring its rigor and validity (Yin, 1994).

While the relationships between the PBO and knowledge source companies were analyzed, along with their connection to executed projects, certain aspects remain inconclusive, leaving room for exploration in future research agendas. Further exploration is required to gain deeper insights into the pivotal relationship factors that influence the

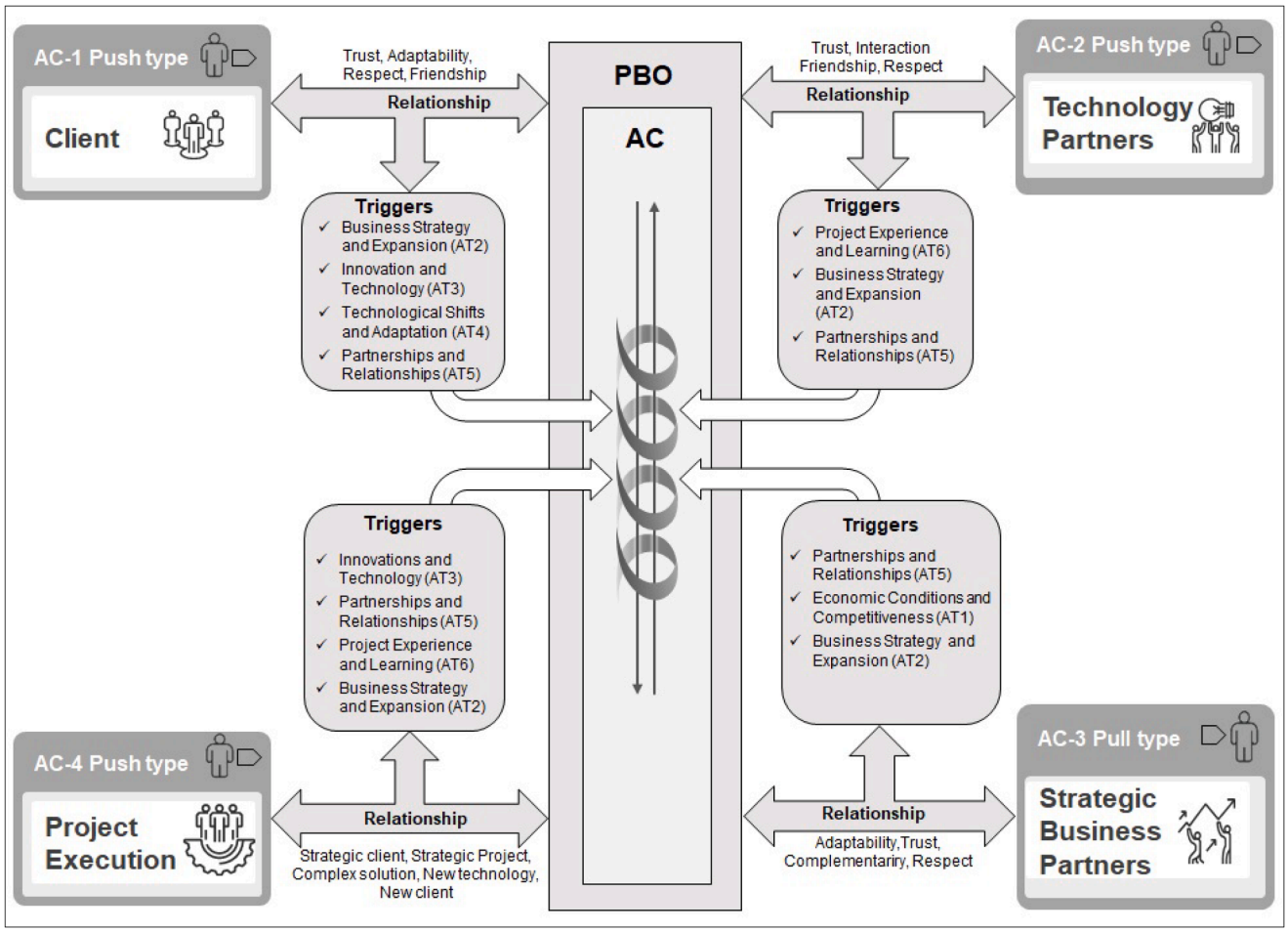

Fig. 8. Framework for developing AC in PBOs.

development of AC within PBOs. This entails examining the perspectives of multiple stakeholders, including project managers, team members, and external partners, to elucidate their views and contributions.

Moreover, a quantitative study could determine the strength and direction of relationships between relationship factors (independent variables) and AC development (dependent variable) exploring potential moderating effects of other variables, such as organizational size or industry sector. Acquiring external knowledge and managing it involves investments. Future research endeavors could investigate how financial management practices impact the initiation, expansion, and sustainability of AC in PBOs. The study has shown that AC can assist the company in seizing identified opportunities; future qualitative research could explore how the knowledge acquired through AC can be effectively transferred to enhance the knowledge within the company's commercial department, thereby improving its ability to sense opportunities.

CRediT authorship contribution statement

Marcos T.J. Barbosa: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Conceptualization. **Marly M. Carvalho:** Data curation, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A – List of projects, triggers and types of AC

Project Index	Year	Project Name	Trigger	Resp.	AC type
1	1996	Automation Projects APC	Immediate client need for plant modernization.	PM3	AC4
2	1997	AAC T3000	Relationship with end customer, experience in electrical installation, and PLC programming. Client recommended SPI to external partner for local manpower.	SA1	AC3
3	1997	PO Box AAC-S10	JWC's numerous projects and client's importation of new lines prompted SPI to form alliances for expansion.	ID1	AC3

(*continued on next page*)

(*continued*)

Project Index	Year	Project Name	Trigger	Resp.	AC type
4	1998	Ammonia Recovery-CNT	Client compared SPI's work to a competitor's, leading to improvements.	SM1	AC4
5	1998	Ammonia Recovery-CNT	SPI sought to expand knowledge in the process industry through a significant project.	PM3	AC1
6	2000	Blue Macaw JCC	Strong relationships with business partners and clients, preparedness, and understanding of the ecosystem.	SA1	AC3
7	2000	Automation of the production of RESA resins	Previous trust relationship with decision-maker at the client facilitated understanding of a new system.	PM3	AC1
8	2001	4300 GA AAC	JWC partner recommended SPI to JCC, emphasizing trust and learning opportunities.	ID1	AC3
9	2001	EPS (Electronic Pull System) AAC	Client opportunity revealed important technology for SPI to learn.	UM1	AC1
10	2002	Projeto 4300 - JWC AAC	Previous experience, trust, and knowledge of the application were important.	SA1	AC3
11	2002	Iron Foundry JCC - AAC	Financial crisis compelled SPI to take on a unique project in the automotive sector.	SA1	AC4
12	2002	AAC Hood and tail gate face lift Astra	Growing robotization projects with more affordable prices.	SA2	AC3
13	2003	APC Industrial Coatings	Cutting-edge system utilizing new technologies in process, IT, and automation.	UM2	AC4
14	2003	Conversion of SCADA system BOC	Strategic opportunity to operate in the oil and gas market with software approved by BOC.	SM1	AC1
15	2003	APC Industrial Coatings	Client's pioneering plant represented a technological shift in the manufacturing process.	SD2	AC1
16	2003	Conversion of SCADA system BOC	Client's need to create a standard prompted SPI's expansion to other markets.	SD1	AC4
17	2004	PHI fermentation system	Regulatory restrictions from Anvisa heightened process attention and pressure to avoid batch losses.	SM1	AC4
18	2004	APC Reactor 20 automation	Challenging project where trust and partnership with the client were pivotal.	PM2	AC4
19	2004	Sistema de fermentação PHI	Adapting to client's needs and staying at the forefront of technology.	SD1	AC2
20	2005	Projeto MÊS REX	Strategic shift to partnerships for portfolio expansion during domestic market crisis.	ID1	AC4
21	2005	AAC Gravatai dash and long cells automation	Knowledge of process and automation architecture.	SA2	AC4
22	2005	AAC Gravatai dash and long cells automation	SPI's competitiveness, ease of budgeting, and client's trust led to business closure.	SD1	AC3
23	2006	JRC robotic cell projects	JRC partner's position change prompted SPI's strategy shift to develop robotic cells.	SA1	AC2
24	2006	JWC In México	Exposure to well-managed projects by JWC and expertise in software and communication.	EM1	AC3
25	2006	JCC JAC HDS Conveyor	Software coordinator's need to master new technology for project success.	UM3	AC3
26	2006	JCC JAC HDS Conveyor	Opportunity to expand partnership and enter the JCM client.	SA2	AC3
27	2006	Flex Net in BAT	Technological partner provided guidelines but lacked necessary workforce.	SD2	AC3
28	2006	Modernization of Nitrocellulose in CNQ	Client's knowledge of productive processes influenced SPI's hiring due to complexity.	UM4	AC3
29	2007	Optimization of the CNT ore drying process	Client felt pressured to improve process performance.	PM2	AC4
30	2008	HF-CNQ	Complex project with a large number of equipment stimulated search for software efficiency.	PM1	AC4
31	2008	JCC JAC Side Conveyor	Learning from partnership consolidation with JCC.	SA2	AC4
32	2008	Andon AAC	Client's standard and significant system architecture change led to SPI's improvement.	SD2	AC1
33	2008	Alive AAC	Strategic partnership crucial with client support and ease of working in the region.	SD1	AC1
34	2009	MES of the BBC glass bottle factory	New client with potential but surrounded by commercial risks.	UM2	AC1
35	2009	Alive AAC	Constant search for task focus and learning from AAC's global standards.	UM3	AC1
36	2011	Reactor Safety APC	Consolidation of new technology for economic viability and expansion in the chemical industry.	PM1	AC2
37	2011	Reactor Safety APC	SPI's competitiveness and long-term involvement with end customer influenced by APC's safety standards.	UM4	AC2
38	2012	Acessment Vale Sul	Partnership with IBM sought to boost business as a service area partner.	UM1	AC3
39	2013	Automation of the algae oil generation plant - BUG	Client migration and technology shift tied to SPI's software implementation.	SM1	AC2
40	2013	Implementation of DCS system - JFC	Shift from DCS to Rockwell system important for learning.	UM4	AC1
41	2014	PDAI Project BMC	Diversification of client portfolio by undertaking new projects.	SA1	AC1
42	2014	MP Parts JWC AAC	Strategic partnership with JWC and trust from the client in the investment region.	SD1	AC4
43	2015	CMES - BEC	Good relationship with client from previous small projects positioned SPI favorably.	UM2	AC1
44	2015	ATC Projects	Government regulation prompted need for a global partner in the pharmaceutical industry.	ID1	AC2
45	2016	High Density AAC	Previous successful projects led SPI to undertake a risky project with adaptation to the business model.	EM1	AC1
46	2017	Hiro Doors GEM GVT	Exposure to partner with cutting-edge knowledge and complementary skills.	EM1	AC4
47	2018	Buyoff Japan marriage system SCS JCC	Learning from low performance in a previous project.	UM3	AC4
48	2018	Marriage SCS AAC JCC	Learning stimulated by low yield and analysis of lessons learned.	UM3	AC4
49	2018	Marriage SCS AAC JCC	Project complexities created learning opportunities and attracted strategic partner's interest in Brazil.	SD1	AC4
50	2019	Automation of seedling selection	Partner's indication led to agribusiness diversification strategy.	SA1	AC4
51	2019	Modernization and expansion of Chemical's production cell	Client's high investment in plant modernization and expansion enabled the use of cutting-edge technologies.	PM1	AC1
52	2019	Woo AAC System Simulation	Client's indication of restricted technology and limited knowledge of the competition.	SD1	AC2
53	2021	Drug Serialization and Traceability	Traceability law seen as an opportunity to enter the pharmaceutical market and gain scale.	UM2	AC2
54	2021	BUG	Scalability potential and use of known MES software expanded learning in agribusiness.	SD2	AC4

PM: Project Manager, UM: Unit Manager, SM: Sales Manager, SA: Solution Architecture, ID: Innovation Director.

Appendix B – Summary of the research questionnaire

1. Could you provide some background on your tenure at the company and your current role?
2. Can you identify projects that have contributed to your personal growth and, consequently, to the company's development?
3. What was the project about, what was its scope, and what was your role in it?
4. What did you learn from your relationships with the partners involved?
5. Which individuals within the partnership influenced you?
6. What challenges did you encounter, and how were they resolved?
7. What previous knowledge was necessary for you to work on the project?

8. Have you improved this knowledge?
9. Did you actively seek out this knowledge, or did you learn it passively, simply by being there and having to absorb it?
10. What kind of pressure was there for you to learn this new knowledge from the partner?
11. Have you acquired new knowledge? If so, from what sources and what types of knowledge?
12. What factors or situations do you believe triggered this knowledge acquisition?
13. Has the company actively sought out technology trends from strategic business partners, customers, technology partners, or other sources?
14. What kind of relationship exists between the company and the partner company from which knowledge was derived?
15. What facilitated learning with this partner?
16. Now, for each of the projects you considered important for your learning and the company's learning, let's rate the relationship factors: interaction, trust, respect, friendship, reciprocity, common language, complementarity, similarity, and compatibility.
17. Can you identify any other relationship factors that were significant for learning with partners?

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