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Fostering SME's co-development of innovative projects in biotech clusters: Extending the sets of enablers for the knowledge creation process

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ABSTRACT

We explore the linkage of specific sets of enablers for the knowledge-creation process (KCP) mobilized in innovative projects co-developed by biotech SMEs and the role of industrial clusters in easing the access to enablers. Two French and one Brazilian high-tech SMEs belonging to two biotechnological clusters were investigated. Deductive and inductive approaches were applied in a complementary manner. Findings revealed a larger set of enablers at the company's level than predicted in the literature. We identified two sets of KCP enablers at the cluster's level, classified as open access and restricted access, which are used for different purposes and simultaneously. These dynamics enabled the studied SMEs to improve their co-developed innovative projects in a more effective way. Data also revealed that the enablers that benefit SMEs are more likely provided by the cluster organisations.

1. Introduction

This research intends to contribute to the body of literature about the knowledge-creation process (KCP), which is considered a key success factor for innovation and organisational transformation [1]. Most research relies on the seminal socialisation, externalisation, combination, and internalisation (SECI) model of Nonaka and Takeuchi [2] to analyse the spiral shape of a creative KCP [3–7]. Another large part of the literature concentrates on enablers of KCP viewed as critical for the emergence of innovation within organisations [5,8].

Whilst researchers have looked at how enablers could permit KCP stages to transform tacit knowledge into explicit knowledge within an organisation [9], we propose to enrich this literature in two complementary ways that relate to the critical questioning of easing access to enablers. First, the existing KCP research focusses on the internal level of companies. In this article, we look at innovative projects co-developed by SMEs, that is, the KCP in an inter-organisational relationship. We then investigate enablers fostering the transformation of discoveries into innovations at the inter-organisational level when companies cooperate, which leads to our first research question: *What are the specific enablers of the KCP for fostering innovative projects co-developed by SMEs?*

Second, we address the cluster context to identify the way the governance of the cluster offers access to enablers that can help the inner companies to foster conjoint innovative projects. We use the general term *governance* to designate the actors in charge of the strategy and management of the cluster to target its mission. From a general overview, the literature has especially established that clusters enhance the KCP [10–12] and could compensate for the lack of internal SME's resources.

Specifically, the significant literature body on clusters already proved that this agglomeration strategically enhances collective efficiencies [10,11]. In addition to providing financial resources to SMEs, the cluster offers a way to animate the social interactions that occur within it by promoting social meetings for networking and sharing information and knowledge [13]. Although knowledge is one of the most important enablers for the KCP, physical resources (such as incubators, accelerators, and laboratories) are also important and are provided by cluster organisations in high-tech industries [14,15]. Then, the access to knowledge, social interactions and physical resources can become available to SMEs through the clusters.

Although the KCP is a key element for high-tech SMEs to create innovations, and the cluster is a catalyst-governed structure to allocate

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and disseminate resources to the inner companies, little attention is paid to *how* SMEs' KCP is shaped by the availability of enablers provided by clusters and *what* the cluster's role is for SMEs' KCP in co-developed projects. We then propose our second research question: *What is the role of clusters in easing access to enablers for fostering innovative projects co-developed by SMEs?*

Our research field comprises two biotechnology clusters, which is a knowledge-based industry [16]. The biotech industry is highly dependent on research and development (R&D) efforts, public-private investments, and venture capital, and it is characterised by fast-changing dynamics and uncertainties [17–19]. Companies in this industry seek to overcome the mentioned difficulties by forming an inter-organisational strategy of clusters, mainly because this agglomeration facilitates access to various assets [20]. In turn, these assets provide companies with new competitiveness levels, cost reductions and enable the emergence of new forms of innovation. We especially look at the EUROBIOMED biotech cluster located in Southern France and at two biotech SMEs developing joint innovative projects, and to the APL Biotec cluster located in South-eastern Brazil and at one biotech SME involved in conjoint R&D-based projects.

Regarding technology in society (TIS) research gap, this research addresses established theories for analysing biosocial-technical systems via new combinations of the well-established Knowledge-Based View (KBV) theory [21]. We intend to fulfil this TIS research gap due previous research targeting TIS were not focusing the KCP and SMEs within clusters. For example, research conducted by Hsu and Yuan [22] focused on university's knowledge transfer, while Nonaka, Umemoto and Senoo [23] focused on information technology (IT) and organisational knowledge creation theory. Thus, the new theoretical development of this research, based on KBV, relates theoretical advancements of KCP in the biotechnology industry and extending the identification of enablers needed in this dynamic and multilevel process. Our contribution is twofold: (1) identify KCP enablers for joint innovative projects, and (2) specify the role of companies and of the cluster in easing access to enablers.

This article is structured as follows. After this introduction, we present a literature review to identify the KCP and its enablers and industrial cluster specificities. We next describe our research design followed by a section that presents the empirical analysis and discussion. We conclude by suggesting further streams of research.

2. Literature review

2.1. KCP and its enablers

In the business management literature, knowledge management (KM) enablers are considered critical elements for an organisation to achieve efficiency in knowledge-related activities. The seminal contribution of Nonaka and Takeushi [2] identified the first set of enablers, or "enabling conditions" for the KCP, as shown at the top of Fig. 1.

Although Nonaka and Takeushi [2] identified the seminal enabling conditions of KCP, these authors did not advance any theories about the enabling features and roles in the KCP. Despite the rich literature on KCP enablers, it is noteworthy that enablers are considered only at the company's internal level. Companies need to establish relations with outside firms to overcome their information access limitations [12] and to access new knowledge [10,11]. Skilled experts are key in these relations due to the tacit knowledge [24] they can share with others [17].

Co-developed innovative projects are very important in high-tech industries, where key and core knowledge is often dispersed among various skilled experts [25–30] belonging to different companies or other kinds of institutions. Whilst this knowledge, per se, is a crucial element at any innovation development stage, the early stages of the KCP are characterised by idea generation, new knowledge creation and scientific research [9,31]. Sharing specific knowledge at different KCP phases with partnered companies leads to an accelerated process, which results in reaching innovations more quickly than competitors [32]. This is the main reason SMEs partner in co-development of innovative projects.

The collaborative projects of high-tech SMEs are usually characterised as network-based, linking SMEs and other organisations to access specific enablers [33,34]. However, contrasting with the focus on an internal innovative project developed by one company, the literature has given very little attention to enablers that ease access to the KCP in the context of co-development of innovative projects of SMEs. We propose to identify the enablers found in the literature, mainly at an internal level, so that, during our empirical investigation phase, we can use this list to identify the enablers in the field.

First, because a critical part of knowledge for innovative projects is tacit [2,9,32], social relations as enablers for facilitating access to sharing knowledge are crucial [9]. Social relations occur through

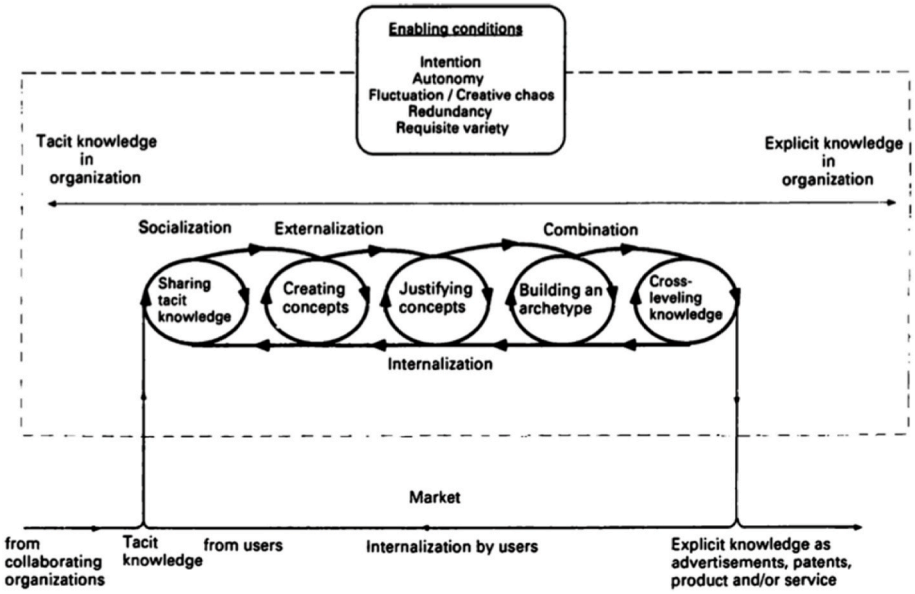

Fig. 1. The five-phase model of KCP. Source: Nonaka and Takeushi (1995, p. 84).

collaborations, cooperation and interpersonal interactions [12,13,35–40]. Some authors have identified the key role of skilled experts [17,24], especially when they act as brokers [41] in identifying and translating knowledge to be shared. In the same vein, knowledge flows through gatekeepers and communities of practices [27,42]. The main objective of this diffused network is to capture the knowledge available to organisations to accelerate their discoveries [43].

Social relations also occur through formal meetings, communities, and project teams [12]. Another part of the literature stresses the role of information and communication technology (ICT) platforms [7,9,12,17,24] established or used by companies for sharing knowledge.

Other enablers relate to key physical resources that can be used in the KCP, such as specialised tools/equipment, as well as basic raw materials common to a specific industry, even gaining access to a production scale achieved through partnering with other organisations.

When we especially look at collaborative projects which require "win-win" negotiations, clear roles and responsibilities, a customer-oriented approach, and the exchange of specialised knowledge [34]. Access to enablers is also achieved through the management style and the way CEOs negotiate with other partners. KCP is context dependent and initiating or maintaining interrelations is not always a clear process [4].

It thus proves from this review that, in cutting-edge industries [39], the more complex the innovations are, the larger the set of enablers that SMEs need from external sources [44–47].

We summarise the main contributions in the literature of the diversified enablers and the specificities of the biotechnology/pharmaceutical fields to classify enablers according to different dimensions and associated categories. Table 1 shows the results of different contributions from the literature, based data analyses.

2.2. KCP enablers and the supportive role of clusters

In our research, we adopt a cluster-level perspective to address how enabler access created through the cluster fosters companies' KCP. We consider a cluster to be an inter-organisational system in which companies find advantages, such as geographical and knowledge proximities and social interactions, from joining with the other cluster actors [48,49]. Knowledge is also created at the cluster level when such collaboration animates its members to disseminate knowledge, which can result in specific enablers. This explains why companies agglomerate to gain access to this specialised knowledge from other partners within the cluster [50,51]. As result, both competition and collaboration may arise from the companies when cooperating by sharing information/knowledge, establishing conjoint research projects (trusted collaborations) and competing for fundraising and government's incentives [49,52,53]. These benefits are supposed to enable inner SMEs to gain access to a greater and varied set of enablers to create new knowledge [10–12,53–55].

Most research on industrial clusters and knowledge creation investigate the roles of social interactions in supporting knowledge creation. The research has found that cluster governance initiatives and support, as well most active cluster organisations (such as universities, research laboratories, accelerators or incubators and experts from different organisations), aim to provide environments and events for social interaction and networking among different inner organisations [13,56]. Thus, knowledge dissemination among cluster actors plays a key role because the cluster acts as a specialised community that leverages knowledge creation and transfer [57]. These social interactions occur via formal and informal interchange of information/knowledge and trusted relations that made up collaborations and are crucial for strengthening the community sense of these inner organisations [56,58–61].

The main goal of such social interactions is knowledge and information sharing provided by inner companies and other organisations (such as universities) of the cluster, resulting in interdependencies [49,56,62–65]. The shared information provided by the cluster should include specific knowledge of the industry, market niches and new trends in the technology domain, which is provided by spillover organisations and/or experts [13,26,58,66]. Clusters also help reduce costs through collective technology development [67] and permit companies to consolidate their innovation and ideas, as well as to secure growth and sustainability. Moreover, the cluster also provides resources that can be exploited by companies in order to develop their innovation in a faster way [1].

Another important role of clusters stressed by the literature is the supportive activities in providing financial resources via government incentives and/or fundraising for projects [13]. In addition to financial resources, a cluster's governance may support inner companies by giving privileged access to key physical resources, such as those provided by incubators, accelerators, and university laboratories [14,15].

Table 1
KCP enablers retrieved from the literature.

Dimensions	Categories	Enablers
Social	Organisational culture	Culture (collaboration, trust, and learning) Trusted collaborations Organisational culture and leadership
	People	Personal attitude, self-directedness, openness to change, personal reflection, skills, tacit knowledge
	Social interactions	Information sharing, communication, formal/informal meetings
Management	Organisational characteristics	Structure (decentralisation, low formalisation)
	Strategic management	KM strategy, efficiency, processes, system perspectives, business innovation, corporate governance
	Power	Negotiation, management style of CEO
	Network	Informal communities, team projects to obtain knowledge, external interactions, knowledge flows, gatekeepers, communities of practices, suppliers
Technology	Information technology	Technology infrastructure, ICT tools Organisational system, resource supports
Resources	Physical infrastructure	Laboratories
	Resources (raw materials or inputs)	Raw materials, specialised tools/equipment, basic raw material, production scale from partnered organisations Cost reduction

3. Research design

This research is based on a deductive and exploratory approach [68] and was carried out through comparing multiple cases [69]. The unit of analysis was the KCP between SMEs involved in an industrial cluster in one biotechnology industry, which includes scientific discoveries for human health in the pharmaceutical domain [16,70,71].

3.1. The research fields: the EuroBiomed cluster, the APL biotec cluster, and the selected SMEs

The Bioméditerranée cluster is located in Southern France, and the political and administrative headquarters is located in Marseilles. De Francisco [72] described how the French government developed a national policy about competitive clusters, which was enacted in 2005 [73]. This policy aimed to support initiatives in creating innovative projects among economic and academic actors. Nowadays, this cluster is composed of 292 firms, the majority of which are SMEs, with more than 30 research centres and higher education institutions and more than 40 other partners [74].

Its main constitutive organisations are the university hospitals in Marseilles, as well as faculties in the health sciences domain located in

the Luminy Science & Technology Park. This particular cluster was begun in 1982 through the creation of the Centre of Immunology of Marseilles-Luminy. This centre was created by researchers to develop and produce reagents from monoclonal antibodies for research and diagnostics [75].

The 'APL Biotec' cluster arose from one incentive from Brazilian government for developing biotechnology industry nationally [76]. This cluster received national support from policies [77], through funding allocated to the APL Biotec, located in Belo Horizonte (Brazilian's state of Minas Gerais). This cluster emerged in 1999 from the Biominas foundation actions, an agent specialised in supporting biotech business, and was considered the leading agglomeration in Latin America in the biotechnology industry [78,79]. This cluster is characterised by the presence of diversified organisations related to universities (UFMG among others) and research centres, syndicates, organisations for the support of biotech businesses (FAPEMIG, IEL/FIEMG, SEBRAE/MG[1]), and an intellectual property centre (NUPIBIO). Moreover, the cluster grouped more than 120 companies (about 30% of the total of biotech companies existing in Brazil), from which the majority is SMEs.

The companies pertaining to this cluster are products manufacturers and services providers in the human and animal health domains, providing diagnostics, manufacturing heart valves, products and by-products in ophthalmology and bone reconstruction. The cluster also possesses companies at embryonal stage of development in the pharmaceutical products domain.

In this article, we focus on three non-subsidiary SMEs located in these clusters, in the same biotechnology industry, and that have partnered for developing conjoint R&D projects. Their main characteristics are summarised in Table 2.

3.2. Data collection and analyses methods

We conducted interviews, lasting three recorded hours, with the CEOs of the three companies [80]. First, we prepared a literature review with a semantic categorisation of the literature [80] by identifying key themes/enablers in publications indexed in international databases. These adopted procedures followed the precepts of Beliaeva et al. [81].

Second, we created a research instrument for data collection (a semi-structured guide of questions) that was based on an in-depth literature review on the subject by using the theoretical saturation precept [82–84]. This instrument was revised according to its content by two experts in the field of Knowledge Management. After building the case study protocol, we conducted a pilot case with a Brazilian company[2] to identify needed adjustments in the research instrument.

Third, primary data were generated by semi-guided interviews and secondary data were collected [69] to ensure source triangulation. External validity [69] was fulfilled by the choice of studying SMEs in the same domain (human health biotech industry). The secondary data comprised information retrieved from the SMEs' websites, reports, and notes from EuroBiomed cluster meetings, Biominas Foundation reports, and the CEOs' curricula vitarum.

The first validation procedure consisted in empirical data validation made by SMEs' CEOs. Each case under study formed a database comprising the 'case database'. Each of the interviewed CEOs revised all the case database, comprising a) transcribed interviews, and b) information retrieved from SME's website, cluster's reports.

The empirical data were analysed in two ways and in two stages:

- Data were analysed according to their thematic content [85] and then reduced (separated, prioritised, interrelated and then categorised) [68]. This content analysis was performed using a thematic type [86]. Data reduction resulted in 462 items and were grouped into three tables, representing the three studied SMEs.
- The case comparisons were developed for a deeper synthesis of crossed cases from the results, generating a typology of a general case in one merged table [69] (the result of such procedure is presented in Table 3, and represented in Fig. 2).

The second validation procedure adopted was the content and analysis validations. Results from the two previous presented data analyses were inspected by the two experts in the field of Knowledge Management (previously mentioned in research instrument validation), procedures which have been validated after minor modifications. The third validation stage was carried out when the results were inspected by the supervisor of this research (author 2), resulting in three modifications of Table 3. The fourth and last phase of validation was reached when the final report (comprising the cross-cases analyses) was inspected by two other experts in the field of Knowledge Management and qualitative research. After reviewing the final draft, it was approved after slight modifications. The tactics used to ensure the validity and reliability of the research were in accordance with Drucker et al. [87].

Empirical findings allowed the cases comparisons by categorising each set of enablers retrieved from the field research in accordance with the enablers found in literature. It was also possible to identify the specific enablers of the KCP used in the studied cases and what role these clusters played in easing access to these sets of enablers, as shown in Table 3 and in the Discussion section.

The three studied case studies allowed the construction of a schematic representation (Fig. 2) of the dynamics between the companies that co-developed innovative projects and their relations with the cluster's level organisations following the recommendations of Ferasso, Takahashi and Gimenez [88].

4. Findings and discussions

The data collection demonstrated that data were rich and detailed, sometimes intertwined, and the SMEs reported much evidence regarding the enablers they constantly used in their KCP. The following results come from the field research and were summarised and, therefore, compared and categorised according to the enablers found in literature (Table 3). The cases datasets were inspected for categorising in data analyses and were guided by the theoretical saturation precept [82–84], that is, the saturation was applied to data retrieved from cases analyses.

4.1. The specific KCP enablers for co-developed innovative projects of SMEs

In this section we analyse the enablers that are related to the company's internal level.

The CEOs expressed their willingness to co-develop projects because of the advantages that would contribute to the KCP of each company. The companies proved to have gained competitive advantages from the overall capability of the partner to compensate for some of their weakest core competences. These advantages are critical for co-developed projects, since having access to complementary peripheral competences complement their internal lack of knowledge. The importance of this co-development was underlined by the CEOs: "*these projects are R&D projects, but they have an impact that goes beyond product development; it is the access to knowledge! It is a very important factor for accelerating knowledge*" (CEO of company 1), "*our business model will be based on partnered research with other companies*" (CEO of company 2), and "*then you have a partnership, you are somehow sharing the risks*" (CEO of company 3). (These findings are labelled as "Competitive advantages of conjoint projects" in Table 3. Other labels from Table 3 are identified in

[1] FAPEMIG: Research Support Foundation of the state of Minas Gerais; IEL/FIEMG: Euvaldo Lodi Institute/Federation of Industries of the state of Minas Gerais; SEBRAE/MG: Brazilian Micro and Small Enterprises' Support Service of the state of Minas Gerais.

[2] The first author who conducted the field research works at a Brazilian university.

Table 2
Companies profiles.

Companies	SME 1	SME 2	SME 3
	Located in the Eurobiomed cluster (France)		Located in the APL Biotec cluster (Brazil)
Domain and core competence	Specialised in the discovery and development of innovative drugs for the control of cell mobility, especially geared to pathologies associated with the nervous system, alteration of cell mobility and unmet medical needs. The company has an exclusive license, a technology platform and worldwide coverage.	Focussed on the development of vector molecules and vectorised drugs that open new ways for drug distribution in the central nervous system, brain and spinal marrow and the treatment of diseases of the central nervous system. The firm is investing in a platform technology through joint development agreements in R&D with other biopharmaceutical companies to generate patents for new chemical entities of drugs produced by its partners.	R&D specialised company for vaccines research and manufacturing in the domain of animal and human health. This company also provides consultancy services related to technology development for its customers (other companies in general). The firm is involved in conjoint projects for developing pharmaceutical products with its customers (other companies in the cluster). The company partnered with an university for developing basic research for patenting.
Main products	Identifies targets associated with adhesion molecules, such as PSA-NCAM and neuropilin. The research conducted by the company staff developed control keys to enhance endogenous neural regeneration, increase plasticity of neuronal network and inhibit the proliferation and migration of cancer cells.	Develops vector molecules that combine drugs and drug candidates, which usually cannot enter the brain. Develops a family of peptide vectors, conjugate vectors, or drug candidates, bio-services, knowledge databases, and co-development.	Vaccine preparation with recombinant proteins processed and other technical-operational support. The company is co-developing also one vaccine for veterinary use. Consultancy services for technological co-development. Acts as outsourced developmental company to the clients (other companies) in order to develop clients' R&D capacities.
Milestones	The first clinical trials were initiated in 2008 in patients with severe trauma to the spinal cord.	Biotechnology start-up, spin-off from the laboratory UMR 6184. The company received support from CNRS (National Council for Scientific Research in France) and the University of the Mediterranean. The firm was established in December 2005.	Launched in 2006, the company is an incubated company at Federal University of Minas Gerais. Classified as scaling up startup, the company is focusing on R&D and services providing in technological development through consultancy services. Along its history, the company made profits from royalties obtained from co-development of projects with customers for developing conjoint vaccines, technology licencing, consultancy services, and technology transfers.
Potential market	Spinal cord diseases: about €600 million. Mild cognitive impairment and Alzheimer's: about €6 billion. Glioblastoma: about €700 million.	Highly targeted drug delivery: about US$6 billion.	Focused on the Brazilian market, the Brazilian government would be the main buyer of new vaccines. However, due the unavailability of data on the national market, the potential Brazilian market for new vaccines R&D is unknown.
Conjoint project	Both companies are working on a co-developed project according to their specialisation to find scientific solutions in order to better target rare brain diseases, passing blood barriers and increasing the success of drug delivery for rare cancer treatments.		The company partnered with one university for co-developing of basic research projects that could result in patents and technology transfer. The company co-develops two vaccines projects with two different customers from the cluster.

Source: the authors.

parentheses in the next paragraphs).

Evidence showed that the three companies used specific knowledge from within each company to create a new product, learned how to manage processes required for the new product creation ("knowledge on how to create a product") and accessed specific information regarding the market niche for the companies ("specific information about the industry").

Acceleration is one of the main concerns for three companies, and there were three identified enablers related to such concern. The companies were able to accelerate their projects, once the higher-performing partner assisted the lower-performing partner in the less-developed project's phase ("access to fast developer accelerate internal processes"). The companies' goal was to go fast, because speed is key in the biotech industry, to create the value needed within a short development time frame in order to achieve patentable innovations ("capacity of accelerating internal processes of development"). The capacity of speeding up development processes was key to attracting new investors because the faster the company can go, the faster will be the return on investor's investments ("capacity to accelerate a project to become attractive for investors").

Empirical evidence showed two main enablers for strategic positioning related to the ability of the companies to attract financial resources. The first related to competition among companies in order to approve funding for their R&D needs from national and international competition announcement ("competition for fundraising"), reflecting the capability of the companies to attract financial capital by analysing their competitors and cutting-edge discoveries in the field ("capacity of attracting capital"). The second aspect was collaborative research to reduce costs and sharing the risks by partnering in conjoint projects ("collaborative research as internal costs reducer").

The results obtained by the companies' R&D, such as intellectual property and patents, were used as bargaining power to attract greater resources, such as funding from public agencies/governments or from private investors or business angels, and to attract future partners/clients for new co-development projects ("bargaining power"). Competences in science and business management were reported to be the two core components of the companies' growth ("science and management competences"). Another identified factor was the ability to attract investments based on the high skilled personnel, innovation, and intellectual property ("investment attraction").

The CEOs proved to be active participants in searching for different assets and partnerships needed by the professional team at the internal level of each company. The CEOs also led several initiatives that enabled each company to have access to different types of assets used in their KCP ("company's initiatives"). Moreover, the business models of these companies were based on strategic partnerships for R&D and product manufacturing ("business model based on conjoint research").

The CEOs collaborated with each other (for the French companies) and with a university (for the Brazilian company) to share specific information and knowledge related to how to manage their internal team,

Table 3
Data summary table on KCP enablers.

Enablers According to the Literature			Enablers Induced from the Empirical Findings		
Dimensions	Categories	Enablers	Enablers at Company Level	Cluster's Level	
				Restricted Access Enablers	Open Access Enablers
Social	Organisational culture	Culture (collaboration, trust and learning) Trusted collaborations	Access to partners' assets through trusted collaborations		Trusted collaborations with partners
		Organisational culture and leadership	Competitive advantages of conjoint projects Company's initiatives	Cluster initiatives/ support Efforts to accelerate the general processes of the companies	Cluster governance animation
	People	Personal attitude, self-directedness, openness to change, personal reflection, skills, tacit knowledge	Collaborations among personnel	Available experts	
	Social interactions	Information sharing, communication, formal/ informal meetings	Specific information about the industry	Meetings for business opportunities	Specific disclosed industry information Disclosed market information Knowledge spillovers Social interactions
	Proximity	Geographical proximity			Geographical proximity
Management	Organisational characteristics	Structure (decentralisation, low formalisation)	Capacity of accelerating internal processes of development Life cycle stage influences		
	Strategic management	KM strategy, efficiency, processes, system perspectives, business innovation, corporate governance	Access to fast-developing internal processes Knowledge protection	Collaborations for cost reduction	
	Power	Negotiation, management style of CEO	Bargaining power Investment attractions		
	Network	Informal communities, team projects to obtain knowledge, external interactions, knowledge flows, gatekeepers, communities of practices, suppliers	Knowledge sharing	Access to specific information and knowledge	
Technology	Information technology	Technology infrastructure, ICT tools	Technology infrastructure	National databases of knowledge	
		Organisational system, resource supports		Access to privileged information	
Resources	Physical infrastructure	Laboratories	Access to partner's laboratories	Access to laboratory infrastructure of partners	
	Resources (raw materials or inputs)	Raw materials, specialised tools/equipment, basic raw material, production scale from partnered organisations Cost reduction	Financial and human resources Collaborative research as internal cost reducer	Access to raw materials from partners Access to equipment/ production scale of partners	
Emerging Elements from Field Research (Not found in the literature)					
Social	People	Competences – skills	Science and management competences		
Management	Financial issues	Access to financial resources	Fundraising capacity Royalty revenues	Financial incentives Financing options Local public investors	
		Access to political incentives for industry development	Capacity of attracting capital	Access to public funding	
	Strategic management	Strategic partnerships	Development versus risk assessment Business model based on conjoint research Strategic partnerships aiming intellectual properties	Funding for partnered projects Access to specific knowledge through partnerships Access to market and industry information	External partnerships to access knowledge Partnerships to search for external funding sources Community of practices
		Strategic positioning	Competition for fundraising Capacity to accelerate a project to become attractive for investors		Collective promoting activities
		Power and politics			Bargaining power Political party to influence the funding choice
	Value creation	Value creation	Employees' new competence acquisition Creation of intellectual property Knowledge on how to create a product	Access to knowledge-enabling value creation for companies Cluster as accelerator of company's development	

(*continued on next page*)

Table 3 (*continued*)

Enablers According to the Literature			Enablers Induced from the Empirical Findings		
Dimensions	Categories	Enablers	Enablers at Company Level	Cluster's Level	
				Restricted Access Enablers	Open Access Enablers
Resource	People	Human capital	Human capital as main resource		
Technology	Technology transfer	University-industry technology transfer		University-industry technology transfer	

Notes.
'Enablers according to the literature': represents the enablers, categories and dimensions found in literature (Table 1) that were used as categories for analysing reduced data (see section 3.2).
'Enablers induced from the empirical findings': evidence from empirical cases that were reduced and categorised according to the enablers found in literature. These enablers were also categorised according to two different levels: those enablers identified at the company's internal level (Enablers at Company Level), and those at the Cluster's level (divided into restricted and open access enablers).
'Emerging elements from field research (not found in the literature)': comprises enablers identified in the empirical findings analyses that were not identified in the literature. In this case, the enablers were classified according to the existing dimensions previously identified from literature.

which improved the managerial performance of each CEO ("collaborations among personnel") and aligned with the literature regarding collaborations among skilled experts [12,36,40]. Collaborations were used by both companies to gain access to the other partner's physical laboratorial infrastructure, which resulted in cost reductions ("access to partners' assets through trusted collaborations" and "access to partner's laboratories").

Another key factor in the management dimension was the influence of the stage in the company's life cycle. At the beginning of a company's life cycle, clusters can help companies grow through obtaining funding, information, and cooperative projects. Companies then need to extend their networking, which was also provided by the clusters. Then, the needs migrated from the financial needs for surviving in the first stages, to networking and partnering for development in the current stages of companies' life cycles ("life cycle stage influences").

Because the companies are in a knowledge-based industry, the created knowledge was managed in order to avoid its leakage. This was a precaution the companies adopted to protect the knowledge aimed at producing innovations (i.e., marketable new products, critical tacit knowledge, prototypes, and patentable information). Additionally, the companies keep core information related to processes in secrecy ("knowledge protection"). The findings showed that the companies shared their knowledge through established relations among their personnel in a relatively open way, that is, they shared knowledge required for the co-development of their projects ("knowledge sharing").

The companies' assessments of their co-developed projects were based on their risk assessment, that is, the greater their ability to develop, the lower they perceive their risks. As a result, the companies could enter the market earlier, which is accelerated thanks to the co-developed projects ("development versus risk assessment"). The main resources that the companies looked for in a partner were financial and skilled personnel ("financial and human resources").

The companies rely on R&D activities, which required a significant amount of financial resources coming from different sources, such as fundraising via contests, public subventions, commercialisation of intellectual property, profiting from royalties and licencing, commercialisation of basic services/products and trading consultancy services. This was and is a critical asset for the three companies and is managed by each CEO in order to achieve the best cost-benefit results ("fundraising capacity").

The companies received royalties from traded intellectual properties and technology transfer with other partners. Although the companies proved to have benefitted from these royalties, each company exploited them in individual ways. By trading their intellectual property, each company reinvested their profits in new R&D projects, such as the co-developed projects under analysis ("royalty revenues"). Whilst it is known that high-tech companies/industries are sensitive to financial issues, there was no enabler in the literature that could be directly linked to financial issues in co-developed projects. Empirical findings showed that the financial dimension is critical, and enablers came up from both levels - the company and cluster levels. Regarding the financial dimension, at the company level, there was a constant concern in the three companies about how to obtain more financial investments and reduce costs internally and to enhance manufacturing scale.

The main goal of the companies in establishing collaborative research was gaining access to each other's intellectual property ("strategic partnerships aiming intellectual properties"). The companies created their value in the market thanks to their intellectual properties or patents ("creation of intellectual properties"). The way these companies created value was and is through the constant way employees acquire new competences and knowledge ("employees' new competences acquisition").

We also identified that human capital is an important enabler and considered a core capital for the three companies at their birth stage ("human capital as a main resource"). The companies also proved to use extensive ICT tools for research, laboratory testing, using specialised equipment and software in data analyses, and information storage ("technology infrastructure").

4.2. *The role of the cluster in easing access to a cluster's organisational enablers*

Guided by the second research question, we focussed our attention on the meso level of the networked partnered organisations. We identified two different groups of enablers at the cluster level, which we named "restricted access" and "open access". Restricted access enablers are those limited to the companies that co-developed projects, whilst open access enablers are available to any company located in the cluster.

4.2.1. *The restricted access to enablers*

The organisations associated with the cluster give access to their experts as a way to strengthen the cluster companies. The studied companies established relations mainly to gain access to specific knowledge in the biotech industry from these experts. The cluster advertise available experts to the inner companies, allowing the experts to circulate among the companies and working in the same scientific domain ("available experts").

The cluster's organisations provided several access points to the inner companies in terms of specific information and knowledge of the industry, skilled experts and a diversified set of services and outsourcing equipment/production scale capabilities ("access to specific information and knowledge" and "access to equipment/production scale of partners"). This confirms that the specific infrastructures available in clusters contribute to fostering scientific discoveries of the SMEs (Clarysse et al., 2014).

Specific information and knowledge are available thanks to strategic

partnerships targeting innovations ("access to specific knowledge through partnerships"). Moreover, studied companies benefitted from the cluster organisations' collaborations for cost reductions in their internal processes ("collaborations for cost reduction"). These cluster access points accelerated the company processes of product development ("efforts to accelerate the general processes of the companies") resulting in value creation and innovations ("access to knowledge enabling value creation for companies").

As expected, the empirical findings are aligned with the literature on clusters regarding access to knowledge from partners [50,51] and the sharing of specific information [13,26,58,66]. Although the literature about clusters stressed that collaborations occur to enhance open information sharing [13,26,58,66], the restricted access to information in the cluster organisations is not clearly addressed in literature, remaining a novel finding from our empirical cases.

The access to funding was one of the key needs reported by the companies for leveraging their KCP, and we found three main points of access for enablers. Companies that are formally associated with the cluster's governance may benefit from the access to several kinds of financial incentives from public agencies at local, national, or international levels. These incentives, targeted to the cluster's companies and managed by the cluster's governance, intend to foster companies' development and growth. This support by the State includes plans to obtain returns on incentives in the future by taxing the successful companies ("financial incentives"). Cluster members benefit from accessing financing options through the cluster's governance and financial entities, such as banks. Among the options, the two French companies benefited from lower bank interest rates for buying expensive equipment and laboratory infrastructure ("financing options"). Because the cluster is a national public body, the governance for the partnered projects provided preferable access to funding as way to leverage cluster competitiveness. This is a way the national government has found to incentivise the co-development of a greater number of innovative projects in the industry ("funding for partnered projects"). The financial dimension is stressed in the literature regarding cost reduction through services [67]. The role of the cluster organisations regarding financial issues was broadened with empirical evidence from the studied companies.

The cluster's governance stimulated investors to meet CEOs and boards of directors of the partnered cluster's organisations. These business meetings brought together public investors and companies and provided fruitful business partnerships. The three studied companies already benefitted from the access to these investors in meetings and were successful in partnering with local public investors ("local public investors" and "meetings for business opportunities").

The cluster also eased access to public funding, mainly from governments at different levels, reinforcing the political role of the cluster ("access to public funding"). Additionally, the cluster's governance had relevant initiatives and supportive activities that favoured the French companies by offering financial aid to participate in business meetings and scientific events in the industry within the country and abroad ("cluster's initiatives/support").

The cluster also eased access to market information (such as competitors, state of product development in the field and consumer markets), which was available through restricted access only ("access to market and industry information"). The cluster, as a political body, had access to privileged information that is shared with the companies ("access to privileged information"). Additionally, the cluster's governance and universities associated with the cluster provided access to national and international databases of current knowledge in the biotechnology domain containing research papers, patent databases and reports ("national databases of knowledge"). In the Brazilian cluster, a university eases the technology transfer to the company 3 through university-industry agreements ("university-industry technology transfer").

The biotechnology industry deals with specific and complex knowledge requiring a variety of equipment and raw materials. The three companies collaborated to have access to other cluster organisations' facilities, mainly universities and laboratories, in order to use their laboratorial infrastructure at different phases of development ("access to laboratory infrastructure of partners"). Access to key raw materials is provided mainly by public universities and research organisations in the cluster ("access to raw materials from partners"). Because of the overall restricted access, all CEOs reported that clusters are key accelerators for their company's development ("cluster as accelerator of company's development").

4.2.2. *The open access to enablers*

The cluster's organisations also favour access to industry information for their inner companies, that is, a relatively open access to information coming from other worldwide companies and scientific discoveries in the field ("specific disclosed industry information"). Other information for the studied companies came from the consumer market and specific market niches provided by cluster organisations, even not fully precise in the case of Brazilian company ("disclosed market information"). All companies benefitted from universities and academic institutions that provided knowledge access acting like spillovers (mainly academic researchers and incubators) through sharing current ideas that are being discussed in academia ("knowledge spillovers").

Companies benefitted indirectly from the access of public investments that the clusters attracted from different political parties, because specific political parties sometimes prioritise industries that can benefit the cluster, which was seen both in France's and in Brazilian's clusters ("political party to influence the funding choice"). Moreover, the cluster's governance has an important political role in advertising the cluster's representativeness in a national scenario, resulting in greater funding and resource attraction for the inner organisations ("bargaining power").

The geographical proximity among organisations facilitated face-to-face meetings promoted by the cluster's governance ("social interactions"). Because most of the associated companies and cluster organisations were located in Marseilles and Belo Horizonte (the headquarters of each cluster), meetings reinforced trusted ties and facilitated the establishment of partnerships. Then, access to enablers was facilitated by trusted collaborations with organisations that were geographically close ("geographical proximity"), augmenting the social interactions that occurred within these cluster [62–65].

The clusters' companies were not competitors with each other, and they were willing to share information and knowledge that might be not critical for their patent/intellectual properties with other companies at the cluster level. They have trust in their collaborations because the companies intended to contribute to the creation of a supportive communities in which all participants have stronger developed partners to exchange with. When a certain degree of disclosure is needed for assessing the possibility of partnering in co-developed projects, the companies sign a secrecy agreement ("trusted collaborations with partners").

Both clusters' governance acted as a gatekeeper in easing external ties with specialised entities if the needed enablers were not available within the cluster. The companies benefitted from external ties intermediated by each cluster's governance ("external partnerships to access knowledge"). Moreover, each cluster's governance has a role in animating social interactions among inner organisations by sharing information and experiences ("cluster governance animation").

As reported by the CEOs, both clusters have an important supportive role by promoting several exchange activities among the organisations, aiming to create a community of practices ("collective promoting activities" and "community of practices"). The companies also provided evidence that they were supported by each cluster's governance when they needed to establish partnerships with external funding agencies that the companies were not able to reach by themselves ("partnerships to search for external funding sources").

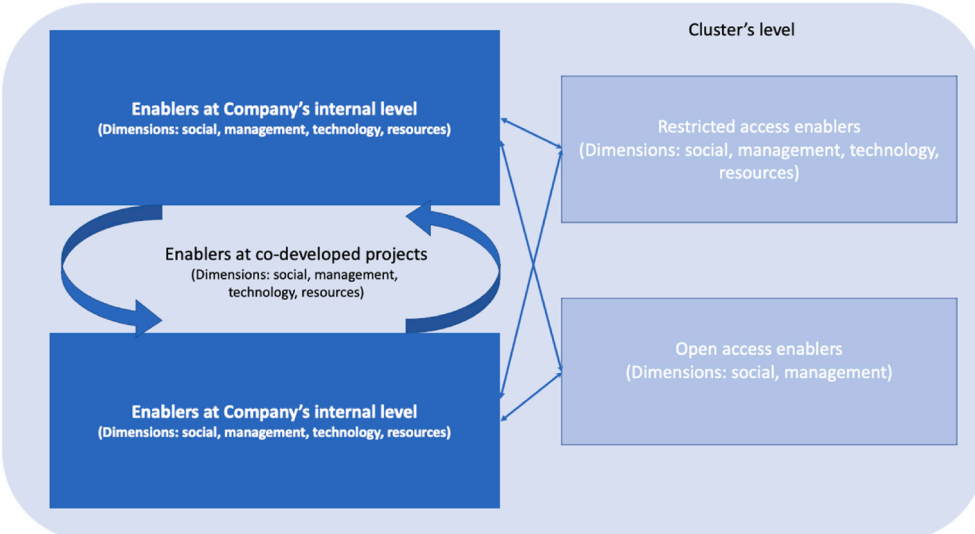

Fig. 2. The multilevel interplay of enablers mobilized in co-developed innovative projects. Source: the authors.

The several enablers identified in the three studied cases allowed the construction of a schematic representation (Fig. 2) of the interplay of these enablers between companies that partnered for the co-development of innovative projects. The multilevel, represented by the cluster's level (light blue in Fig. 2) allows the representation on how the open and restricted enablers are linked with each company.

The connections between the two different levels (the cluster's organisations that provide the restricted/open access enablers and the company's internal level) shows how dynamic is the KCP in co-developed projects, involving the enablers that are mobilized specifically to the co-developed project, the enablers that exist in the company's internal level, and in which way the company retrieve externalities from cluster's level, namely from the organisations embedded in the cluster as well as the cluster's governance.

5. Concluding remarks

This research targeted two different research questions: 1) What are the specific enablers of the KCP for fostering innovative projects co-developed by SMEs? and 2) What is the role of clusters in easing access to enablers for fostering innovative projects co-developed by SMEs? Our research showed that there are more KCP enablers for innovative projects co-developed by SMEs than those found in the literature. We also showed that these enablers operate at two levels: at the company's internal level and between companies that partnered for co-development of innovative projects (cluster's level).

The study revealed that there are diversified enablers developed at the same time and in a constant and dynamic way when two companies were trying to achieve successful results through their co-developed projects. Achieving faster developments was one of the main reasons that companies partnered and established strategic collaborations with the cluster's organisations. Another factor was the search for resources they did not possess and the role of the cluster in easing the access to those externalities.

The studied companies benefitted from the managers' knowledge of how to manage a high-tech company in order to obtain the needed externalities. As a result, companies profited from a "growing cyclic management process": the more positive results KCP managers obtained via effective management practices, the better the company developed its partnered projects.

Empirical evidence also showed that the cluster favoured access to an extended and diverse set of enablers to acquire and absorb information, knowledge and specific assets that are used internally by each company in their co-developed projects. The cluster also played a key role in strengthening and stimulating the emergence of co-development projects within companies to foster innovations in the industry.

Addressing the TIS research gap, this research contributed to the field by identifying how complex biotechnology knowledge is for creating innovative solutions to the market niche by the studied companies. The combination of KBV for studying biosocial-technical system [21] allowed the identification of a more diversified set of enablers than predicted in literature. Moreover, the three case studies provided insights on how the several KCP enablers are used together, especially when companies are working on the co-development of innovative projects. Thus, this research advanced the previous TIS studies by going beyond the knowledge transfer [22] and understanding the implications of organisational knowledge creation theory in real world companies. This research provided novelties to the Knowledge Management field by addressing the biotechnology industry dynamic KCP in a multilevel perspective.

This study provides contributions for practitioners, for example, high-tech company owners/managers, by searching for key enablers that may foster the management of their companies and identify the role of a cluster in fostering their KCP process. Biotech owners/managers may assess the future of their businesses by forecasting the enablers in the next stages of their company's life cycle by strategically planning the set of enablers could be needed as co-development projects evolve.

As suggestions for future research, we first recommend the replication of this study to compare it with companies and their KCP process in other high-tech industries. Second, our findings demonstrate the large scope of enablers that can benefit companies when they develop joint innovative projects. We postulate that the more companies are strategically involved in joint projects, the more they will encourage enablers to succeed. Finally, enablers sharing seems to demonstrate a certain degree of trust between the companies involved in a joint project. We suggest research to investigate the relation between the level of trust among companies and the scope of enablers shared.

Author statement

Conceptualization: MF; Data curation: MF; Formal analysis: MF and CG; Investigation: MF; Methodology: MF; Project administration: MF; Resources: MF and CG; Software: MF; Supervision: CG; Validation: CG; Visualization: MF and CG; Roles/Writing - original draft: MF; Writing – review & editing: CG.

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Authors' contributions

Research project, data collection, data analysis, draft writing, MF; revising draft, data presentation, supervision, CG.

Declaration of competing interest

The authors declare no conflict of interests.

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