CHARACTERIZING THE SUCCESS OR FAILURE OF COLLABORATIVE INNOVATION PROJECTS BEYOND THE TANGIBLE OUTCOMES

Abstract

This paper aims to identify the intangible outputs of a collaborative innovation project. Indeed, the outputs of innovation are discussed in the literature through the prism of performance or in terms of indicators. However, given the importance of resources, skills and knowledge from a strategic point of view, it seemed crucial to measure their impact following a collaborative innovation project. The determinants of a failure of a collaborative innovation project and of the process are studied. The work of this paper is based on 20 qualitative interviews of collaborative innovation projects in the HealthTech industry in France. The literature is based on the concepts of innovation, resources, skills and knowledge, as well as the collaborative aspect of the project, its management and its challenges but also when the innovation is considered as a sucess. The first part of the results focuses on the background of collaborative projects for innovation. All agree that they choose their partners for the complementarity of resources, skills and expertise. Then, the collaborative process, its challenges and its management are studied in the second part. The issues are related to the differences between the organizations involved in the project, the management of which is composed of formal and informal mechanisms. Finally, the results in fine of the projects are analyzed in the last part of the results. Our results show that measuring innovation is not enough to characterize the success or failure of a collaborative innovation project. By considering innovation as a process and not only as an outcome, but we can also consider the resources and knowledge needed to achieve this process. The results also highlight that the benefits of a collaborative innovation project must be considered beyond the success or failure of the innovation project. Indeed, it appears that the interviewees consider the entire project experience as a success rather than the commercialization of the innovation *in fine*.

Keywords: *collaborative innovation projects, success, intangible outcomes, knowledge, health tech industry*

1. Introduction

Firms collaborate to develop innovations (Chesbrough, 2003; Cohen & Levinthal, 1990; Tether, 2002). Indeed, firms strategically collaborate to access to new knowledge (Cohen & Levinthal, 1990; Nonaka, 1998), to access the partners complementary resources (Cassiman & Veugelers, 2006; Le Roy et al., 2016) or to benefit from cross-fertilization (i.e. exchange, disseminate and share knowledge and resources between different stakeholders to create new ones) (González-Piñero et al., 2021). However, the performance of collaborative innovation projects is often discussed (Janger et al., 2017; K. H. Smith, 2005). This performance is often measured by the output, the performance of the innovation assessed either by a binary variable (development of the innovation or not) or by the number of patents (Coombs et al., 1996; Hagedoorn & Cloodt, 2003; Schentler et al., 2010). However, the objective of companies that get involved in collaborative innovation projects is not limited to the development of innovations, but also include the increase of their innovation capabilities. In this vein, companies can participate to collaborative innovation projects to access additional sources of resources and knowledge (Grant, 1991; Un & Asakawa, 2015) and learn from their partners (Grant, 1996; Mudambi, 2008; Prahalad & Hamel, 1997). Thus, the development of innovation might not be the only benefit of a collaborative innovation project and intangible benefits could be expected. This observation therefore raises the questions of how to measure the success or failure of a collaborative innovation project? Is the development of innovations the only output of collaborative innovation projects? How measuring the intangible outputs of collaborative innovation projects?

To answer these questions, we conducted a qualitative exploratory study of 19 collaborative innovation projects in the HealthTech industry.

The results of this study show that the failure of the innovation does not mean the failure of the collaborative project. Firstly, partners' motivations for engaging in collaborative innovation

projects are predominantly focused on the acquisition and development of new resources and knowledge. Secondly, we highlight the managerial challenges of collaborative innovation projects regarding the sharing and protection of resources and knowledge. Thirdly, in the last part, we study the outputs of collaborative innovation projects beyond the development of innovations.

These results present three major contributions to the literature on collaborative innovation. First, we contribute to the debate about the definition of the success/failure of collaborative innovation projects. Second, the importance of taking intangible outputs into account in collaborative innovation projects (skills, resources, knowledge, etc.). Thirdly, the confirmation of the importance of the complementarity of resources and skills but also their development during the collaborative innovation process.

2. Theorical framework

2.1.Antecedents of collaborative innovation projects

Companies participate to collaborative innovation projects for several reasons. A first objective is to reduce the costs and risks associated with innovation (Jorde & Teece, 1990). Collaborations, particularly for R&D, enable firms to save on their costs by pooling their different resources (and skills, knowledge) (Dussauge et al., 2004; Tether, 2002). Other objectives are important such as the internal valorization of their know-how, the reduction of the time-to-market and the development of new products/markets (Cassiman & Veugelers, 2006; de Faria et al., 2010; Santamaria & Surroca, 2011). A major objective of collaboration for innovation is access to complementary skills and know-how ((Bogers & Horst, 2014; Kang & Kang, 2010). Firms look for complementary resources and knowledge to foster the development of innovations and to improve their innovation capabilities. R&D allows firms to improve their absorptive capacity, i.e. their ability to assimilate and exploit new knowledge

(Cohen & Levinthal, 1990). Part of knowledge management would therefore also involve the effect of learning and experiencing new knowledge. This absorption capacity would enable the firm to be in a better position to imitate new innovative products or processes.

Firms can decide to collaborate with a large variety of partners. However, the success of R&D collaborations depends on the choice of partners (de Faria et al., 2010; Le Roy et al., 2016). Existing literature agrees on the importance of the choice of partners in the collaborative process. The choice of partners is also a question of sharing the risks associated with the production of an innovation.

Partners' choice is also influenced by the type (product or process) and degree of (radical or incremental) of the innovation developed (Le Roy et al., 2016).

When the partners have complementary knowledge and technologies, the added value of the final project and its outcome is enhanced by the cross-fertilization of these resources (González-Piñero et al., 2021). In addition, prototyping in collaborative projects improves the "overall" prototyping process, through cross-fertilization (Bogers & Horst, 2014). The process of open and collaborative innovation allows for an iterative process of creation and 'problem solving' between partners. Moreover, the prototyping of an innovative product would be the main repository of cross-fertilization of knowledge. It would serve as a platform for sharing knowledge, skills and resources through the complementarity of the actors involved in the project.

The choice of partners depends on three criteria (1) whether the potential partners are competitors or not; (2) whether the collaboration aims to produce an incremental or radical innovation and (3) the geographical location of the competitors (Le Roy et al., 2016). It appears that for product innovation collaborations (regardless of the degree of disruption), collaborating with customers has more (positive) impact than one with suppliers. In contrast, collaborating with an academic partner would be beneficial for innovation (radical or incremental) (Le Roy

et al., 2021). R&D collaborations with customers and academics have a positive impact on the development of innovation (Kang & Kang, 2010). Internal R&D activities and external knowledge acquisition are complementary (Cassiman & Veugelers, 2006). For example, the dependence of the innovation process on academics (as a source of information) would strongly influence the choice of partners (Cassiman & Veugelers, 2006). According to the authors, it is therefore crucial to integrate internal and external knowledge, to improve the innovation process of the company. It appears that firms from high-tech industries with high levels of absorptive capacity (Cohen & Levinthal, 1989) and investment in innovation place more value on partner choice (de Faria et al., 2010).

2.2. Managing collaborative innovation projects

2.2.1. Tensions in collaborative innovation projects

Collaborative innovation projects can provide several benefits, but they also raise several managerial challenges. Existing literature has identified several tensions in collaborative innovation projects (Das & Teng, 2000; Estelle & Mrm, 2018; Le Roy & Fernandez, 2015; Lewis et al., 2010; Loan-Clarke & Preston, 2002). Paradoxical tensions are contradictory but interdependent elements (W. K. Smith & Lewis, 2011). They exist simultaneously and persist over time. They are logical when considered separately but inconsistent when considered together.

Tensions in collaborative projects are mainly due to the structures and relationships between individuals (Lewis et al., 2010). For example, in collaborative innovation projects between an academic and a private organization, tensions come from different logics - the importance of academic research versus practical need - different time frames and rigor of the research process versus the benefits of the research (Loan-Clarke & Preston, 2002). Furthermore, collaborative innovations projects can lead to asymmetrical results (Dussauge et al., 2004). The resources

pooled by the partners play an important role in the value creation of the collaboration. The distribution and 'alignment' of these resources has an impact on the alliance - and thus the collaboration (Das & Teng, 2000). The success of the alliance is affected by the relationship between the partners and the choice of resources shared (or not). But the 'partner' aspect may have more impact on the alliance than the nature of the resources (Lavie, 2006).

Because tensions can lead to conflicts and might risk ending the collaboration, they need to be managed.

2.2.2. Managing collaborative innovation projects

To manage tensions, firms can rely on several formal and informal mechanisms. Previous studies have highlighted several formal mechanisms (Fernandez et al., 2018, 2018; Le Roy & Fernandez, 2015; Mothe & Quelin, 2001; Olk & Young, 1997). First, formal agreements such as consortium agreement (Mothe & Quelin, 2001) establish formal rules to manage collaborative innovation projects. For instance, consortia agreements help companies to formally structure a project (Mothe & Quelin, 2001; Olk & Young, 1997). A consortium can be defined as two or more companies sharing (proprietary) information and resources to create a new legal entity to carry out R&D activities. The members of a consortium frequently create a new legal entity. Consortia agreements facilitate the pooling of resources, skills and knowledge that cannot be accessed in any other way (Mothe & Quelin, 2001). Consortia would also facilitate the transfer of resources, skills and knowledge and facilitate the creation of new resources (Mothe & Quelin, 2001).

Second, firms can implement formal principles such as the separation principle or the co-management principle (Le Roy & Fernandez, 2015). The separation principle consists in separating functionally collaborative activities from internal activities. The co-management

principle invites partners to jointly govern their innovation projects (Le Roy & Fernandez, 2015).

Third, organizational designs offer solutions to formally manage the knowledge flows (Le Roy & Fernandez, 2015). While joint project teams are relevant for radical innovations, separate project teams are recommended for incremental innovations (Le Roy & Fernandez, 2015). Joint project teams are suitable for radical, risky and costly innovations that require an intense pooling of knowledge from the partners. However, the risk of opportunism is high in this type of joint project team. Therefore, joint project teams will not be used to develop incremental innovations because they are less costly and less risky, they require less knowledge sharing from the partners(Fernandez et al., 2018). This organization design limits the sharing at the coordination of interfaces between project teams.

Finally formal tools such as information systems can be used to manage information flows in collaborative innovation projects (Fernandez & Chiambaretto, 2016). They allow firms to share critical information for the project success while protecting non-critical and sensitive information from the partners.

These formal mechanisms can be combined with informal mechanisms to efficiently manage tensions in collaborative innovation projects. To manage knowledge flows, firms can rely on the culture of secrecy or the hidden agenda (Hamel & Prahalad, 1991). The knowledge sharing between project members is essential for the project success but individuals are torn between sharing knowledge among project members is essential for project success, but individuals are torn between not sharing information for fear of risking losing a valuable source of competitive advantage or sharing information and advancing the project (Cabrera & Cabrera, 2002). Coordination mechanisms by which firms assimilate and integrate knowledge are also important (Grant, 1996). Management by the (hierarchical) top management would be one of the keys to the assimilation of this knowledge. Managers orchestrate the integration of

knowledge into the firm's processes. Knowledge is held by employees, and therefore by individuals. It is therefore up to them to exploit and exercise it within the organization. The manager must therefore reconcile organizational problems with the 'incompatibility of individual goals'.

2.3.The success of collaborative innovation projects

Innovation can be considered as an outcome of collaboration innovation projects. It can be measured by the degree of disruption of the innovation (Davila et al., 2012; LOILIER & TELLIER, 2013) or by the purpose of the innovation (Schumpeter, 1943). However, innovation can also be considered as a process and not 'only' as an outcome (Rothwell, 1994).

Existing literature has paid significant attention to the measure of the success, outputs and spillovers of collaborative innovation projects (Archibugi, 1992; Coombs et al., 1996; Hagedoorn & Cloodt, 2003). In high-tech industries, the innovation performance was used as a measure of the success of collaborative innovation projects (Hagedoorn & Cloodt, 2003). The innovation performance variable measures the input to research, the importance of R&D activities and the number of new product introductions. These indicators cover the main components of the innovation performance.

Combs and colleagues (2003) provide a review of indicators for measuring innovation. Patents are used to measure innovation performance and the level of innovation production (Archibugi, 1992). However, this measure quantifies the number of "inventions", but there is no assurance of their innovativeness. To overcome these limitations, Narin and Olivastra (1988) suggest considering the number of citations of patents. The more patents are cited (and therefore recognized and "inspiring"), the higher their innovative performance is. Nevertheless, this measure is also limited as it is based only on one part of the innovation process and does not

consider the other stages. These measures seem to be appropriated only for innovations that have already been commercialized.

The "EU 2020" indicator aims to measure the outputs and spillovers of innovations (to then compare EU countries in terms of innovation). However, the indicator based on patents seems too oriented towards the output of innovations (quantification and qualification of the innovations) (Janger et al., 2017). Using patents as an indicator of innovation outputs considerably restrict the measure of the output of collaborative innovation projects.

Schentler and colleagues (2010) measured innovation performance at three levels: corporate level, multi-project level and single project level. They argue that it is necessary to look at different components of the process(Schentler et al., 2010). In order to measure the success of the performance of the innovative project and its outputs, it is necessary to look at the gaps between what was planned in the project and what was achieved (especially from an operational point of view). It is also necessary to compare each project with the other projects in the firm's portfolio.

In a nutshell, previous studies did not reach a consensus about the measures of the outputs of collaborative innovation projects. Most of previous research relied on the quantitative measures of tangible outputs (financial indicators, patents), leaving intangible outputs unmeasured.

2.4.Theorical gap

The success of collaborative innovation projects is mainly measured through the prism of the performance of innovations and by quantitative indicators. However, as previously explained, firms collaborate also to access knowledge that can then be combined with their internal knowledge to enhance their innovation capabilities. We can even suspect that the development of innovation is sometimes secondary and that their primary objective in entering collaborative innovation projects is the acquisition of knowledge. We can thus assume that collaborative

innovation projects do not only aim to develop innovations but can also lead to intangible benefits such as the acquisition of new knowledge. Therefore, we argue that to measure the success of a collaborative innovation project, we need to go beyond the quantification of the innovation to include intangible outputs such as the transfers of knowledge. In other words, the failure of an innovation (commercialization) is not a measure of the success of the collaborative innovation project. Assessing the success or failure of an innovation project is more complex and should include intangible elements. We believe this is essential to understand the impact of collaborative innovation projects of innovation capabilities of the firm. Therefore, this research aims to address the following questions: how to measure the success or failure of a collaborative innovation project? Is the development of innovations the only output of collaborative innovation projects? How measuring the intangible outputs of collaborative innovation projects? To address these questions, we conducted qualitative research of 19 collaborative innovation projects in the HealthTech industry in France.

3. Method

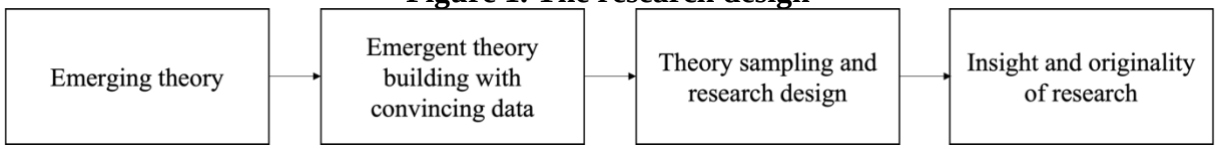
3.1.Research design

Our research aim is to understand the tangible and intangible benefits of collaborative innovation projects for the actors involved, their partners and their sector. Therefore, our study is based on an in-depth exploration of multiple collaborative innovation projects in HealthTech industry. As we seek to enrich understanding of a poorly understood phenomenon—i.e., the outcomes (tangible and intangible) of collaborative innovation projects—we rely on an exploratory case study design (Yin, 2009). This design is appropriate to pursue comprehensive research and examine underexplored phenomena (Eisenhardt, 1989; Yin, 2009). Indeed, our research aim is to understand the outcomes of collaborative innovation projects beyond the success or the failure of the innovation. To address our research question, a multiple case study

(Eisenhardt & Ott, 2017) was appropriate because (1) it allowed us to collect more data, feeding into a larger knowledge base and (2) it allowed an in-depth analysis of each project and comparisons of the projects leading to richer results and potential for better generalization of the results obtained.

Our research followed the process recommended by Eisenhardt and Ott (2017) (see Figure 1). The first step concerns the emergent theory of the multiple cases studied. This step requires well-defined research concepts, a clear relationship between the concepts and a logic that justifies these relationships. In practice, we have carried out an iterative process between the collected data and the existing theories (Chesbrough, 2003; Cohen & Levinthal, 1990; Grant, 1996; Janger et al., 2017; Mudambi, 2008; Prahalad & Hamel, 1997; Schentler et al., 2010) in order to generate new insights. This process aimed to increase the validity of the theories used for the research. Second, we worked on enriching and illustrating these theories with convincing data. To do so, we collected primary and secondary data from multiple sources. In a third step, we defined the theoretical sample of collaborative innovation projects to study their tangible and intangible outcomes. This research design coupled with the definitions of our sample allowed us to limit potential biases in our exploration.

Figure 1. The research design



Source: Adapted from Eisenhardt and Ott (2017)

3.2.Empirical framework

3.2.1. Presentation of the industry

The study is focused on collaborative innovation projects in the HealthTech industry. The HealthTech industry is a high-value and high-tech industry in which innovation is a central

activity. This industry is particularly relevant for this study because it is extremely conducive to the development of collaborative innovation (Giordano et al., 2020). Indeed, in this industry, companies constantly innovate through collaborations with multiple actors (suppliers, customers, competitors, public organizations)

The HealthTech industry is divided into three main sectors: Biotechs, E-health and Medtechs. The cycles of innovation in this industry are relatively long, particularly in terms of research and development (over 15 years). The development and performance of this industry is closely related with the health conditions of the population. The increase in the ageing of the population, the emergence of new diseases and the increase in existing diseases, as well as the emergence of technological means of treatment represent the main growth factors. However, the numerous regulations and new requirements (particularly concerning the introduction of new molecules onto the market) can limit the growth of the industry. In addition, R&D cycles are long and costly, and the return on investment uncertain. Therefore, it is challenging for companies in this industry to innovate. Moreover, the industry is structured around a few large companies but also around a large number of start-ups/biotechnologies. This structure of the industry and the challenges surrounding the innovation process explain that actors are used to collaborate for innovation purposes and that collaborative innovation is a common practice in HealthTech. A lot of new products are jointly developed by competing firms (Le Roy et al., 2021). For example, the vaccine for the covid-19 has been co-developed by Pfizer and BioNTech. Without the pooling of resources from the two competitors, the development of the RNA-Messenger vaccine to combat the Covid-19 epidemic would not have happened as quickly. In order to protect the intellectual property of each partner in projects in this industry, the most common lever used is patents.

3.2.2. Presentation of the multiple case (collaborative innovation projects)

This study is conducted among collaborative innovation projects in the HealthTech industry. The unit of analysis is the project level to observe the innovation process and the benefits of collaboration. We studied in-depth 19 collaborative innovation projects. Table 1 provides further details about each project studied. They all started between June 2007 and January 2017. All the projects ended between October 2011 and March 2020. Four of the projects surveyed were led by a large company, ten by SMEs, three by research centers and two by VSBs (very small businesses). The largest budget allocated was 23.7 million euros whereas the smallest was 0.6 million euros. On average, the budget allocated to projects was €5.79 million. The collaborative innovation project with the most partners was project 1 with 16 partners. By contrast, the minimum number of partners in the project was two. On average, the projects studied had 4.4 partners. Finally, 10 projects belong to the MedTech sector, 7 to the Biotech sector and 2 to the digital health sector.

3.3.Data collection

We collected extensive data from interviews and documents (see Table 2 for further details about the data collection). In total, 20 interviews provided the main data for the study. We conducted interviews in March and April 2021, which allowed us to build a solid understanding of the setting and establish connections with key informants, enhancing research quality. The interviews lasted, on average, about 42 minutes and were conducted in French and then translated to English. When possible, they were conducted face-to-face and recorded on tape. The transcription was done using the AmberScript software. Overall, the interview transcripts represent about 244 pages of evidence. We also compiled approximately 42 pages of handwritten notes, which helped contextualize the interview-based evidence. For secondary data, we used the project book published by Eurobiomed in 2019 (88 pages) and the INPI report

on collaborative innovation from 2012 (120 pages). The project book provided a lot of information about the sector they belong to, the dates of the project, the partners and the purpose of the project. The INPI report was very useful in providing secondary data on the sectors and industry studied.

To limit biases, we triangulated primary data (from interviews) with secondary data coming from reports disseminated by the project leaders and press articles (see Figure 2). This triangulation allowed us to double check the facts at the different stages of the project.

Table 1. The 19 projects studied

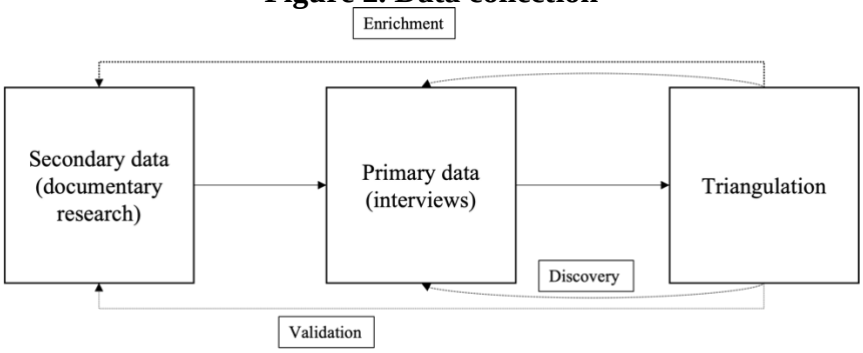
Project	Number of partners	Project leader structure	Project date	Project budget	Purpose of the project	Sector of the project	Length of the interview	Interviewee's role
Project 1	16	Large firm	Nov. 2012 – Dec. 2016	22,4M€	Designing and developing a humanoid robot for human assistance	E-health	01:17:06 00:55:09	Project manager Project manager
Project 2	5	SME	Jan. 2017- Dec. 2019	1,9M€	Developing an interactive and entertaining musculoskeletal system tool for students and health professionals	E-health	00:46:13	Project manager
Project 3	8	Large firm	Jan.2012 – Dec. 2016	13,8M€	Develop an offer in the haematological diagnostic domain	Biotech	00:37:44	Project manager
Project 4	3	SME	Mar. 2011 – Jul. 2015	3,5M€	Developing a diagnostic tool to detect oncogenic papillomavirus DNA	Biotech	00:50:04	Project manager
Project 5	4	Large firm	Mar. 2008 – Sep. 2012	3,2M€	Design and develop a drug candidate and then a diagnostic test for malaria	Biotech	00:44:12	Alliance manager
Project 6	3	SME	Sep. 2012 – Oct. 2019	23,7M€	Design of an automated radiotractor production system for PET molecular imaging	Biotech	00:47:59	Project manager
Project 7	6	Large firm	Oct. 2007 – Oct. 2011	10M€	Develop and market the first cochlear implant	MedTech	00:55:53	CEO
Project 8	4	SME	Mar. 2010 – Aug. 2013	3M€	Developing a drug to fight nervous system diseases	MedTech	00:56:27	R&D Manager
Project 9	2	SME	Jan. 2010 – Jan.2014	3,2M€	Innovative cell-based systems for the discovery of new drugs for metabotropic glutamate receptors	MedTech	00:52:33	R&D Manager
Project 10	4	SME	June 2007 – Nov. 2011	3,1M€	Development of a canine leishmaniasis vaccine	MedTech	00:38:20	Alliance manager
Project 11	3	Center of research	Oct. 2015 – Mar. 2020	2,87M€	Modulation of the glutamatergic synapse using nanobodies	MedTech	00:29:17	Project manager
Project 12	4	VSB	Jan. 2011 – Jul. 2014	2,5M€	Optimisation and standardisation of thyrotropin dosage	Biotech	00:45:55	CEO
Project 13	2	VSB	Nov. 2009 – Oct. 2012	0,6M€	Active satiety by electrostimulation of the vagus nerve for the treatment of morbid obesity	MedTech	00:27:43	Project manager
Project 14	2	Center of research	Janv. 2012 – June 2015	1,9M€	Dock5, a promising new target for osteolytic bone disease	MedTech	00:22:44	PhD
Project 15	2	Center of research	Jul. 2015 – Aug.2018	2,2M€	Validation of MT5-MMP as a new therapeutic target in Alzheimer's disease and mechanisms of action	MedTech	00:26:02	Project manager
Project 16	5	SME	Feb. 2013 – Dec 2017	1,9M€	Optimisation of the nebulisation process for airborne surface decontamination	MedTech	00:19:44	Industrial activities manager
Project 17	2	SME	Nov. 2011 – Aug. 2015	4,8M€	Imaging diagnosis and treatment of prostate cancer	Biotech	00:34:54	Project manager
Project 18	3	SME	Jan. 2013 – Dec. 2016	2,9M€	Treatment of autism with a diuretic: Bumetanide	MedTech	00:37:59	CEO
Project 19	5	SME	Jan. 2015 – Nov. 2018	2,6M€	Development of a TomoSynthesis process on an X-ray table	Biotech	00:27:50	Project manager

Table 2. Data collected

Data collection process			
Primary data			
• Interviews with project managers (11)	• Interviews with CEO (3)	• Interviews with other managers : - R&D Manager (2) - Alliance manager (2) - Industrial activities manager (1)	• Interview with a PhD (1)
Secondary data			
Internal sources		**External sources**	
"Book Project R&D Eurobiomed 2019", Eurobiomed (2019), (88 pages)		"Collaborative innovation and intellectual property, some good practices", INPI (2012), (120 pages)	

The interviews were semi-structured, conducted with the innovation project leaders or one of the collaboration partners. The interviews started with an introduction - presentation of the interviewer and the interviewee, its position in the project. Then, we discussed the different aspects of the collaborative innovation project - the emergence of the project, the implementation of the project, the collaborative process, the difficulties encountered and the outcomes of the project. We concluded each interview by thanking the respondent and asking for additional contacts, in line with the "snowball" effect recommended by Miles and Huberman (1995) (see Appendix 1 for the interview guide) (Miles & Huberman, 1994).

Figure 2. Data collection



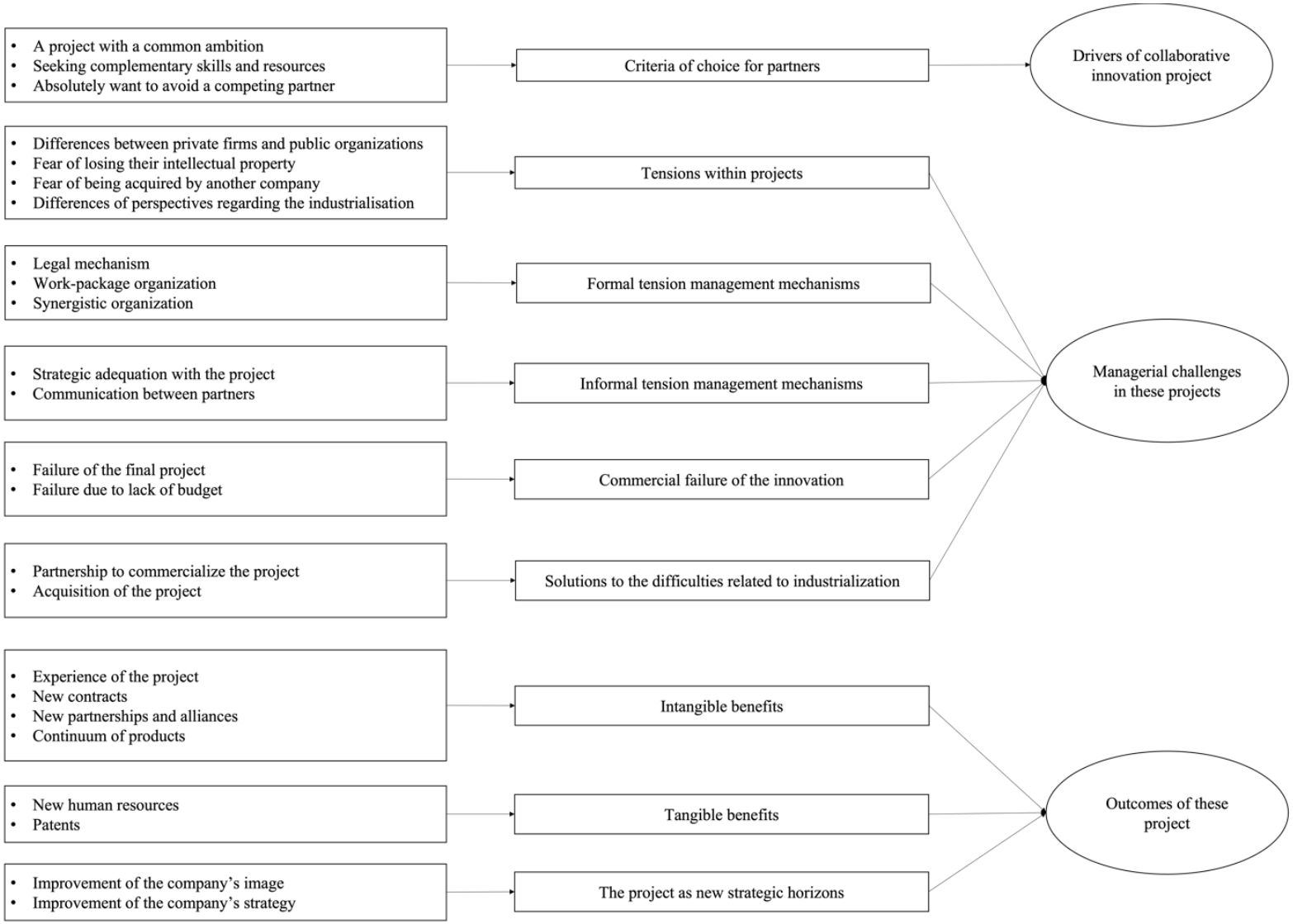
3.4. Data analysis

The data were coded using the data coding software NVivo through systematic procedures, by adapting the "Gioia methodology" (Gioia et al., 2013). Our analytical process involved several steps to effectively capture relevant categories, initiate a theorizing process of the outcome of collaborative innovation projects and reinforce the trustworthiness of our findings. We have iteratively travelled back and forth between our data and the literature to conceptually refine categories and to develop the emerging structure of arguments. Hence, several rounds of coding (Miles & Huberman, 1994) were followed by thematic analysis and by flexible pattern matching (Bouncken et al., 2021). A first phase of "open" coding allowed us understand project characteristics and contextual elements – the partner choice, the objectives of the project, the tensions, the management of the project and the outcomes. Then, a second, more inductive coding phase allowed us to establish links between the 1st order themes and the 2nd order concepts (see Table 3 for an example of coding and Figure 3 for the final coding structure).

Table 3. Example of coding

Quotes from interviews	1st order concepts	2nd order themes
"Things came about through various meetings and **sharing our common interests and goals.**" (Project 3, project manager)	A project with a common ambition	Criteria of choice for partners
"I think, is **the key** in all collaborative projects, is that the **partners need to bring complementary skills**." (Project 19, project manager)	Seeking complementary skills and resources	
"An industrial partner with **whom there was no risk of competition** because we were not in the same business. " (Project 5, alliance manager)	Absolutely want to avoid a competing partner	
"{Academics} have completely **unrealistic** ideas and expectations." (Project 9, R&D manager)	Differences between private firms and public organisations	Tensions within projects
"We felt that 'X' **wanted to redo what we were doing internally**." (Project 1, project manager)	Fear of losing their intellectual property	
"Is there one that intends to **eat the other**?" (Project 9, R&D manager)	Fear of being acquired by another company	
"With more **complicated trade negotiations**.." (Project 1, project manager)	Differences of perspectives regarding the industrialisation	
"Ah, it's all written in the **consortium** agreement! You know there are rules to respect, quotation marks penalties for not respecting the rules." (Project 5, alliance manager)	Legal mechanism	Formal tension management mechanisms
"Well we had a really **star project**, so they didn't have to collaborate with each other basically, you know?" (Project 7, CEO)	Work-package organization	
"On each of the bricks, we had to say to ourselves, 'What do we need to do to have the best chance of it working? As a result, there was **group work**." (Project 19, project manager)	Synergistic organization	
"The product must be fully in line with the company" (Project 10, alliance manager)	Strategic adequation with the project	Informal tension management mechanisms
"You have to have very clear **communication** without ambiguity. That's the key to everything." (Project 7, CEO)	Communication between partners	
"We didn't invent molecules." (Project 5, alliance manager)	Failure of the final project	Commercial failure of the innovation
"It was **too expensive** to manufacture" (Project 1, project manager)	Failure due to lack of budget	
"And then, suddenly, this big company woke up and **agreed to commercialise it**" (Project 2, project manager)	Partnership to commercialize the project	Solutions to the difficulties related to industrialization
"There are others who will pull out the makeup kit to make themselves **look good to be acquired**." (Project 9, R1D manager)	Acquisition of the project	
"(...) It allowed us to accompany the manufacture of a **new product** (...), which has become the **company's flagship product** (...)." (Project 1, project manager)	Continuum of products	Intangible benefits
"It makes **other techniques advance**. There is a lot of know-how and **experience** that has come out of "Project X"" (Project 1, project manager)	Experience of the project	
"Behind that, **we got other contracts** that have nothing to do with." (Project 1, project manager)	New contracts	
"There are also other partnerships, **other collaborations** going on." (Project 3, project manager)	New partnerships and alliances	
"Yes, all the people who came either on a fixed-term contract or on a thesis, we **recruited them afterwards**." (Project 8, R&D manager)	New human resources	Tangible benefits
"Finally what I would call **very good results**, since there were about ten **patents** that were filed in partnership." (Project 3, project manager)	Patent production as a result of the project	
"It's a very competitive market, with huge international players. It's part of the background work to try to have a **more innovative image**. (Project 3, project manager)	Improvement of the company's image	The project as new strategic horizons
"It [the collaborative innovation project] has resulted in a whole bunch of products that today **make us number one in the world** in GPCAs." (Project 9, R&D manager)	Improvement of the company's strategy	

Figure 3. The coding structure



4. Findings

This section is structured according to the process of collaborative innovation: drivers and antecedents of collaborative innovation projects, their implementation and their outcomes.

4.1. Drivers and antecedents of collaborative innovation projects

First, out of 19 projects, 15 explained that when they look for partners for innovation purposes, they look for complementarity. More specifically, the selection of partners was guided by the complementarity of their key resources and skills. As they did not have the necessary resources and knowledge to achieve the innovation alone, they opened their horizons to access them outside their organization.

> *"I think, what is key in all collaborative projects, is that the partners have to bring complementary skills."*
>
> *(Project 19, project manager)*

However, it is interesting to understand why partners accept to pool their resources and knowledge instead of using them to develop in-house innovations. The first apparent reason is to share the costs of research and development, that are particularly intense in the HealthTech industry and in healthcare in general.

> *"It's often like that in fact, because academics don't have... the financial or even industrial resources to do anything behind it, ... They need industrial partners to be able to do it."*
>
> *(Project 6, project manager)*

A collaborative innovation project in the HealthTech sector is expensive to develop. The most expensive phase of a collaborative innovation project is the industrialization phase. Therefore, companies tend to look for partners that are fin favor of the industrialization phase or that could facilitate the industrialization phase:

“There are some who are looking for commercial deals for example.”

(Project 9, R&D manager)

In addition, developing in-house innovation might require the recruitment or training of expert engineers or managers (i.e., individuals holding singular knowledge). However, recruitment or training are time-consuming and expensive processes. It could be easier for firms to access this expertise through collaborations with other actors.

"First we looked for the expertise we needed (...), we always look for expertise first.

(Project 8, R&D manager)

The necessary expertise and complementarity offered by the partners therefore appear to be main criteria for partner selection for innovation, and even more for upstream projects. In addition, partner selection seems to have a strong impact on the project progress.

"We don't know how to do everything; we need to work with people who have skills that we don't have.”

(Project 9, R&D Manager)

However, complementarity of resources and knowledge is not the only aspect to take into consideration when selecting a partner for innovation. For example, some companies deliberately choose to collaborate with a partner with which they also compete on the markets:

"An industrial partner with whom there was no risk of competition because we were not in the same business. It's easier from an operational point of view if there are things to exploit. It's still easier not to mix, not to... and everyone has their own interests.” (Project 5, alliance manager)

4.2.Managerial challenges of these projects

Although collaborative innovation projects can generate several benefits for the project members, they also raise several managerial challenges. Table 4 below details the challenges expressed, their impact on the project and the resulting managerial needs.

Table 4. Managerial challenges in collaborative innovation projects

Challenges	Impact on the project	Managerial needs to handle these challenges	Quotes
The difference in size, culture and way of working between organizations (SME VS large group)	Distrust and incompatibility of working methods	Challenges requiring formal and informal resource and knowledge management mechanisms	*"The cultures, the size, all that yeah, of course that's part of the difficulties." (Project 7, CEO)*
The differences between public and private organizations	Disrupted deadlines and disagreements on the vision of the project (industrialize vs. further research)		*"Academic partners who have different rhythms. (Project 6, project manager)*
Fear of knowledge plundering and competition	Distrust of knowledge plundering	Protection of intellectual property	*"We felt that Aldebaran wanted to redo what we were doing internally." (Project 1, project manager)*
The fear of a takeover by a large group	Distrust of SMEs and VSBs in relation to large companies	Protection of intellectual property and need for financial resources by SMEs	*"Is there one that intends to eat the other?" (Project 9, R&D manager)*

These managerial challenges can generate tensions and conflicts among project members and lead to the project failure. Partners relied on several mechanisms to address them. All the projects we studied were organized as consortia and are governed by contracts. In these contracts, the division of work is formalized in two different forms: work packages and joint works. Work packages allow organizations to divide their tasks and work separately. They tend to have a star-shaped organization. Conversely, joint work packages promote synergies. Partners tend to have a circle organization, interact and share more information with each other. It appears that some projects worked in a “star” organization and others in a “circle” organization. The “star” organization suggests that the partners agree on their role and then gather their "technological brick" at the end of the project. The circle organization, on the other hand, assumes an almost constant synergy between the partners with an adjustment mechanism dedicated to collaboration.

Rather, communication and the habit of collaboration are informal mechanisms for managing tensions. Knowing each other and having worked together before allows projects to create synergies because the partners already know how to work together. Communicating throughout the collaborative process and agreeing on what information, knowledge, and skills to share up front reduces the risk of tensions over intellectual property.

Table 5. Managerial needs related to the challenges

Managerial needs related to the challenges	Management mechanisms in place	Quotes
Challenges requiring formal and informal resource and knowledge management mechanisms	Breakdown of the project into several work packages or work tasks VS. Group work Circle projects VS. Star projects Communication Habit of collaboration	*"The project was in different packages." (Project 3, project manager)* *"We had a really star project, so they didn't have to collaborate with each other basically, you know?" (Neurocom cochlear branch DG)*
Protection of intellectual property and need for financial resources by SMEs	Patents, consortium	*"Intellectual property that is managed by the consortium agreement." (Project 7, CEO)*

4.3. Outcomes of collaborative innovation projects

4.3.1. Tangible outputs of collaborative innovation project

Although all the projects studied did not successfully reach the industrialization phase, we first studied the nature of the innovation of the project. Of the 19 projects studied, 63% aimed to commercialize a product innovation, 32% an innovation combining the characteristics of a product and process innovation and 5% a process innovation. More than half of the innovations are radical (58%) or disruptive (26%). Moreover, 16% are incremental innovations.

Six projects succeeded in industrializing the innovation developed: project 1, 3, 7, 9, 10 and 17. Project 1 aimed at designing and developing a humanoid robot dedicated to personal assistance. The project was led by a large group specialized in humanoid robotics. The consortium had 16 partners: 6 private organizations and 10 public organizations. Project 1 was one of the projects that succeeded with a product continuum after an initial failure. Project 3, coordinated by a large medical device manufacturing group, aimed to develop an offering in the field of hematology diagnostics. It included three private and five public partners. Project 7 is a project led by a major group specializing in hearing aids and aims to develop and market the first cochlear implant. The partners who worked on this project are 3 private companies and 3 public structures. Project 10 aimed to develop a canine vaccine against leishmaniasis. It is composed of three private structures and one public structure, supported by a small company. Finally, project 17 aimed to create an imaging diagnostic tool for the treatment of prostate cancer. It was carried by a medium-sized company, in partnership with a public structure and a private company. Industrialization is the most complex phase for collaborative innovation projects, according to the interviewees.

"And that's where it's tense because that's where with more complicated business negotiations." (Project 1, project manager)

Moreover, it seems that this phase is the most complicated because it requires a lot of financial resources to succeed.

"It's the industrialization behind it [exclaims] that costs [brief silence] in my opinion as much, if not maybe more." (Project 6, project manager)

Despite the challenges of successful commercialization, interviewees shared with us a variety of solutions if the collaboration cannot be completed internally (see Table 6).

Table 6. Solutions for the industrialization phase

Solutions	Quotes
Disclosure of competence or license to a large group	*"And Servier was mandated to do phase 3, bought the European license, and it is Servier that is doing phase 3, not me. Under my control." (Project 18, CEO)*
Create your own structure	*"We stop because we can't find an industrialist, or we create our own company to develop." (Project 11, project manager)*
The acquisition by a large group	*"There are others who will pull out the makeup kit to make themselves look good to be bought out" (Project 9, R&D manager)*

To better understand why some innovations did not reach the industrialization phase, it seemed necessary to look deeper on upstreams phases of the innovation process such as the development stage. The success / failure of the development stage can be assessed by patent registration. In total, 69 patents have been filed and used as a result of the collaborative innovation projects. According to intervieewees, patents are maajor benefits of collaborative innovation projects:

"Finally, I would describe the results as very good, since about ten patents have been filed in partnership" (Project 3, project manager)

Table 7: Patents registered following the project

Project	Patents registered following the project
Project 1	8
Project 2	/
Project 3	1
Project 4	1
Project 5	/
Project 6	9
Project 7	14
Project 8	5
Project 9	1
Project 10	5
Project 11	1
Project 12	1
Project 13	1
Project 14	1
Project 15	/
Project 16	16
Project 17	2
Project 18	3
Project 19	/
TOTAL	**69**

The partners have therefore benefited from the filing of patents. Indeed, intellectual property is distributed according to the contribution of each partner's knowledge in the projects we studied. If companies A and B are in the same collaborative innovation project, if their contributions amount to 50% each in terms of resources and knowledge and if company A files a patent, company B also benefits.

4.3.2. Intangible outputs, even when industrialization fails

When a collaborative innovation project fails (failure measured by tangible outcomes), it can though provide several intangible benefits to the partners such as the acquisition of resources and knowledge and the learning from the experience of failure and an opportunity for new strategies.

Regarding the acquisition of resources and knowledge, all the interviewees mentioned that the collaborative innovation project allowed them to increase their internal resources and their resource portfolio:

> *"There is a lot of know-how, a lot of experience that came out of the project for the company."*
>
> *(Project 1, project manager)*

More than half of the respondents agreed that they increased their skills and know-how as a result of the project, whether it was successful or not. Although commercialization was not successful and they were not able to measure the performance of their innovation, there is success in terms of skills, knowledge and know-how.

"It allowed us to move forward, in a certain way, even if the progress was not positive, but at least it allowed us to... even if the progress was not positive, but it allowed us to at least..." (Project 5, alliance manager)

In addition, most projects had hired staff to work on the innovation project. In total, 159 jobs were created as a result of the collaborative innovation projects for the 19 projects studied. PhD proposals were offered to work on topics related to the collaborative innovation projects.

Table 8: Number of jobs created thanks to the project

Project	Number of jobs created
Project 1	3
Project 2	2
Project 3	1
Project 4	2
Project 5	/
Project 6	21
Project 7	60
Project 8	6
Project 9	1
Project 10	18
Project 11	/
Project 12	6
Project 13	/
Project 14	1
Project 15	1
Project 16	3
Project 17	8
Project 18	10
Project 19	16
TOTAL	**159**

Another intangible outcome of collaborative innovation project is the product continuum, i.e., the learning from the experience of failure. Many of the collaborative innovation projects we were able to study continued the project after its failure by developing a continuum of new products.

"Two products that were followed by a third, (...) actually it's a continuum." (Project 3, project manager)

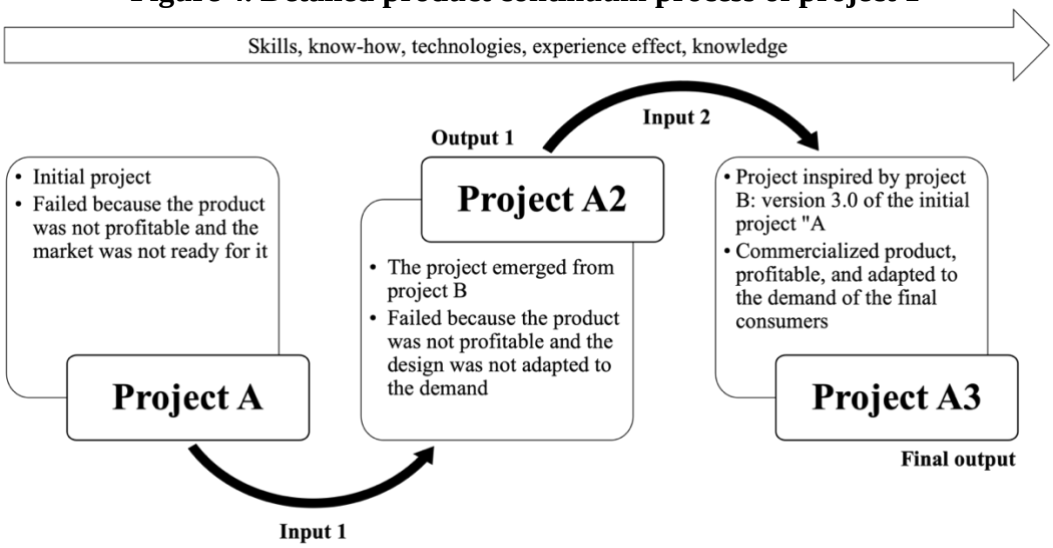
Indeed, 6 out of 10 projects continued to develop a 2.0 version of the innovations after the failure of the collaborative project. To illustrate these product continuums, we study in-depth Project 1.

"It allowed us to support the manufacture of a new product (...), which has become something of a flagship product for the company (...)." (Project 1, project manager)

We decided to divide the project into three main phases (Project A, Project A2 and Project A3). Each phase has its own inputs and outputs. Projects A2 and A3 have as input the failures of the phases that precede them (A and A2).

The original project was Project A. It failed for reasons of profitability. The market was not ready for a large-scale innovation. At the end of this project, the creators of the first project had the idea to develop a new product, project A2. The A2 project was born from the A1 project. The "A2" project was therefore carried out with 16 partners. Project A failed a first time, then was renewed in a product continuum. Project A2 was born, but the product design was not sufficiently adapted to the needs of the end customers and was still not profitable. The A2 project inspired the "A3" project, which was cost-effective and demand driven. It is part of the second product continuum. Figure 4 presents the product continuum of Project 1.

Figure 4. Detailed product continuum process of project 1



The failure of the A1 project thus inspired the successful development of several products and services by the organizations. The last project "A3" was commercialized in 2014, but its sale was stopped in 2021 due to lack of profitability. These projects thus illustrate the "2.0, 3.0... " and the continuum of products launched by organizations following an innovation project (commercial success or not). We can then conclude that the final success (of the "A3" project) was possible thanks to the experience of the two failed projects "A" and "A2

Finally, the collaborative innovation process was also an opportunity for companies to open to new strategies. For example, companies got ideas about new strategies regarding to renew their brand image or to reach a market leader position in the market.

"It is a very competitive market, with huge international players. Even if we are already big, compared to the international players (...) we had more of a follower image, and now we are trying to propose innovations to have another image with our customers and users. It's part of the background work to try to have a more innovative image" (Project 3, project manager)

Furthermore, thanks to the continuum of products developed, some project members have been able to differentiate or specialize. In addition, by expanding their product portfolio, the companies were able to become more competitive. The company piloting Project 9 explained how the products developed by the project allowed them to become a leader in a specialized market.

"It [the collaborative innovation project] has resulted in a whole bunch of products that today make us number one in the world in GPCAs." (Project 9, R&D manager)

Finally, the respondents expressed an opening of the company's borders boundaries more collaboration. Thanks to the experience effect and the image of the project, new opportunities have been seized by the companies. These spin-offs from the collaborative innovation projects are perceived as real benefits by the respondents.

"There have also been other partnerships, other collaborations so...there you go, more things going on." (Project 3, Project Manager)

5. Discussion

5.1.Contributions

This research aims to understand the full benefits of collaborative innovation projects and their successes. We showed that the majority of organizations choose their partners to have access to complementary resources and skills. During the collaborative innovation process, these resources and skills are honed, developed, and shared. Like the habit of collaborating and the project experience, the individuals interviewed consider these resources and skills as a real success for the project, beyond the commercialization of the innovation in fine. These findings present several contributions to the literature.

First of all, existing literature in strategic management explains that innovation is main goal pursued by corporate strategies (Hamel, 1996). A firm can also be described as a set of resources and knowledge (Barney, 1991; Grant, 1991; Prahalad & Hamel, 1990). Our research is in line with these previous studies. First, we provide empirical evidence that firms need to increase their portfolio of strategic resources and core knowledge to develop innovations. As the creation of resources and knowledge is costly and risky, companies rely on collaboration with several partners, based on resource and knowledge complementarities, to access external sources of resources and knowledge.

In addition, our results are in line with previous studies that have highlighted the importance of partner selection – in terms of resource and knowledge complementarity – for innovation purposes (Cassiman & Veugelers, 2006; de Faria et al., 2010; Fritsch & Lukas, 2001; Le Roy et al., 2016). Our research confirms that companies choose complementary partners to advance academic/fundamental research with they share a vision and a common ambition. Regarding the collaborative process and its issues, the extant literature acknowledges that managerial challenges, tensions and conflicts are mainly due to the differences between the partners in terms of nature, objectives, work rhythms, methods, corporate cultures, etc. (Dussauge et al., 2004; Loan-Clarke & Preston, 2002; Markovic et al., 2021). Our research confirms these conclusions. The collaborative innovation projects raised several managerial challenges: differences in size, culture and way of working between SMEs and large group; differences between public and private organizations; fear of knowledge plundering and competition and fear of a takeover by a large group. To deal with these managerial challenges, companies relied on mechanisms: breakdown of the project into several work packages VS group work; circle project VS star project; consortium and patents; and informal mechanisms like communication and habit of collaboration. The use of formal and informal mechanisms to manage collaborative

innovation projects is also consistent some previous studies (Fernandez & Chiambaretto, 2016; Olk & Young, 1997).

Finally, we believe that the main contribution of this paper is about the outcomes of collaborative innovation project. While previous research mainly studied the success or failure of collaborative innovation projects through the lenses of tangible outcomes such as the performance of the innovation (Coombs et al., 1996; Hagedoorn & Cloodt, 2003; Janger et al., 2017; Schentler et al., 2010) we suggest going beyond these indicators to include intangible outcomes in the assessment of a collaborative innovation project. Our findings show that measuring the innovation is not enough to characterize the success or the failure of a collaborative innovation project. When looking at innovation as a process and to only as an outcome, allows us to consider the resources and knowledge necessary to achieve this process. Our findings also highlight that the benefits of a collaborative innovation project should be considered beyond the success or failure of the innovation project. We highlighted spillover effects of innovation projects such as the creation/retention of project-related jobs, the development of new product/service continuums and new contracts or even partners.

5.2.Limitations and research perspectives

Despite its contributions, our research suffers from several limitations that can provide interesting avenues for future research. A first limitation is due to the empirical background of our research. We have studies 19 collaborative innovation projects in a high-tech and knowledge intensive industry, i.e., the HealthTech industry. Even if we believe that this industry can be exemplar of high-tech industries, only further studies conducted in other industries could confirm our findings. In addition, it could be interested to conduct similar studies in more traditional industries (or less knowledge intensive) to discuss the relative importance of

intangible outcomes (the acquisition of knowledge for instance) of collaborative innovation projects.

Another limitation comes from the conceptualization of "intangible" outcomes of collaborative innovation projects, their identification, and their measure. Intangible outcomes are difficult to grasp. Longitudinal case study could be interesting to conduct to study the whole strategic transformation of the resource portfolio of the company, before, during and after the collaborative innovation project.

Finally, our findings suggest considering the project spillovers when characterizing a collaborative project as a success or a failure. In this research, we mainly studied as positive spillovers. However, these positive benefits might be limited by potential negative spillovers due to knowledge plunders or opportunistic behaviors. Future research could study more specifically positive and negative spillovers of collaborative innovation projects and explain how companies' trade-off between them.

6. Conclusion

While existing research success of collaborative innovation projects is only measured in the literature by the quantified performance of the commercialization of the innovation *in fine*. Indeed, less attention was paid to the intangible outcomes. This research aimed to fill this gap by addressing the following research questions: What are the benefits of collaborative innovation projects? Does the success of these projects depend only on the performance of the commercialized innovations? How can we observe and measure the other intangible outputs of collaborative innovation projects?

To address them, we studied 19 collaborative innovation projects in the HealthTech industry. Our findings showed the importance of the resources and skills created, developed and honed within collaborative innovation projects. Also, the notion of know-how and experience such as

the habit of collaboration is to be considered in the success of collaborative innovation projects. Moreover, the success through failure of different projects (s-e. product continuums) is also to be considered. In a nutshell, we invite future scholars to go beyond the evaluation of the innovation and to look at the whole innovation process to characterize the success or failure of collaborative innovation projects. Overall, we believe that the success/failure of collaborative innovations projects remains an intriguing phenomenon that offers exciting research avenues.

Appendix

Appendix 1. Interview guide

PHASE 1: BEGINNING OF THE INTERVIEW	QUESTIONS FOR CLARIFICATION or EXPLORATION
Introduction of the interviewee - *Can you introduce yourself?* - *Could you present the structure to which you are / were attached during the XXX project?*	*Can you tell me a little more about it?* *Can you tell me more about them?* *How would you define them?* *Can you give me some examples?* *Can you please elaborate?* *What makes you say that?* *Can you elaborate?* *What do you mean by this?* *Can you identify other reasons?*
THEME 1 **THE EMERGENCE OF THE PROJECT** - *Could you briefly present the project and its objectives?* - *How was the initiative structured within the structure to which you are/was attached?* - *Can you tell me about the context of the project?* - *I would like you to tell me about the other partners involved in the project* - *How was the choice of these partner structures made?* - *Who are the actors involved in this project?* - *Can you tell me about the partners' motivations in this project?* **THEME 2** **IMPLEMENTATION AND PROCESS OF THE COLLABORATIVE PROJECT** - *Can you tell me about the different phases of the project?* - *Can you tell me about the organization of your structure during the project?* - *How did you work with these partners?*	

- *How did you share and/or protect information in this project?*
- *What difficulties have you encountered in working with these partners?*
- *Can you tell me about how you dealt with these difficulties?*
- *Can you tell me about the organization of the teams within the project?*
- *What were the operating rules set up between the partners to manage the project? How were these rules defined?*
- *How would you describe the relationships between the different partners involved in the project?*
- *Overall, what do you think could have been improved in the cooperation between partners?*

THEME 3
THE RESULTS OF THE PROJECT

- *What was the outcome of this project?*
- *What were the results of this project?*
- *How would you describe the innovation you have created?*
- *Can you tell me about the industrialization of innovation?*
- *Can you tell me about the benefits of the project?*
- *Can you tell me about the success of the collaborative innovation project?*
- *Can you tell me about the failure of the collaborative innovation project?*

CLOSING PHASE OF THE INTERVIEW

Is there anything else you would like to add that we haven't covered?
I have two final questions:
- Can you think of any documents related to the topic that could help us in our analysis that you could send us?
- Do you know of anyone who was involved in the project and is attached to another structure in the consortium that could provide insight?

Thank you again for your time. I wish you a good continuation.

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