

MESG
MESTRADO EM ENGENHARIA
DE SERVIÇOS E GESTÃO

**SCIENCE AND TECHNOLOGY INNOVATION COMMERCIALIZATION:
SUCCESS FACTORS AND CHALLENGES FOR
ENTREPRENEURSHIP UNIVERSITY**

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Master Thesis

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2021-07-29

Abstract

Covid-19 pandemic had caused huge impacts worldwide. Despite that, there are still few studies aiming to explore science commercialization in the light of the covid-19 crisis and its impacts on new ventures. The commercialization path is crucial for both the regional economies and national competitiveness and its knowledge and understanding become almost mandatory for any organization that wishes to ensure any competitive advantage in the market in the next years after covid-19. In this context, this study aims to explore the science commercialization success factors, limitations, and challenges of start-ups in times of covid-19 getting an overview from the start-up's creation until the expected future.

The methodology applied in this study was qualitative research using exploratory in-depth interviews covering eighteen start-ups in different sectors and maturity stages. The findings from these analyses suggest that there are other types of motivations to start a new venture besides being a university students' entrepreneur and experienced ones. It also gathers information about the new venture's target market, such as why the start-ups choose niche markets, and it was also identified the main actors that compete with start-ups. However, the focus of this study is the success factors and challenges of science commercialization, as well as, the positive and negative impacts of covid-19 found on new ventures.

Key words: science commercialization, covid-19 impacts, success factors and challenges for entrepreneurship university

Acknowledgments

First of all, I want to express my gratitude towards Prof. Maria Gabriela Beirão dos Santos from FEUP and Prof. Ana Torres from INESC TEC for the direction, support, and assistance provided during the development of this study.

To FEUP for providing me with the knowledge and tools to carry out this challenge.

To my mother for always being by my side and the motivation that helped me moving forward.

To my friends and family for the support.

Finally, to the participants of this study that were so helpful and without them, this study could not be done.

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List of abbreviations

AI	Artificial Intelligence
B2B	Business to Business
B2C	Business to Consumer
COVID-19	Coronavirus disease of 2019
INESC	Institute of Systems and Computer Engineering, Technology and Science
IOT	Internet of Things
R&D	Research and Development
UACOOPERA	Transversal Unit of the University of Aveiro for Cooperation with Society
UPTEC	Science and Technology Park of University of Porto

1 Introduction

Technological innovations have created powerful companies that have transformed industries, regions, and society as a whole through new technologies that improve productivity, economic growth, increase jobs and wealth, as well as, enhance the quality of life. Not surprisingly, many researchers are studying how science can be commercialized, emphasizing technology commercialization activities, university-industry collaborations, and academic entrepreneurship (Fini, Rasmussen, Wiklund, & Wright, 2020; Zahra, Kaul, & Bolívar-Ramos, 2018). Hence, science commercialization implies connecting academia and business to bring new scientific inventions, knowledge, and technologies from the research lab to be successfully transferred to the market as an innovation. In other words, science commercialization transcends the scientific and commercial worlds (Clayton, Feldman, & Lowe, 2018; Fini, Rasmussen, et al., 2020). This complex panorama calls for a deeper understanding of how innovation originated from science is exploited and commercialized (Ankrah, Burgess, Grimshaw, & Shaw, 2013; Fini, Grimaldi, & Meoli, 2020). Especially, understanding how innovation will play a crucial role in the economic recovery process after Covid-19 (Chesbrough, 2020; Nurhayati, Endri, Aminda, & Muniroh, 2021).

This chapter provides some context over the project developed and is divided into three sections: the project context, the main objectives, and an overview of the report's structure.

1.1 Context

Companies are constantly under pressure to change with the increasing complexity of products and processes combined with the accelerated rate of technological transformation and short life cycle of products, which has led to a growing R&D (research and development) investment and commercialization cooperation between organizations. In this context, the commercialization of science is a complex process that dictates inventions must be successfully transferred to the market. So, the success of science commercialization depends on the interactions between companies and institutions in the scientific and technological system. This commercialization path is crucial for both the regional economies and national competitiveness, and it depends on the innovation type and the risk run with the commercialization and cooperation between the organizations (Kirchberger & Pohl, 2016; Mascarenhas, Ferreira, & Marques, 2018).

Hence, the importance of knowledge and technology exchange between universities and firms has long been acknowledged. The economies and innovation levels of industrialized countries bring to light that their productivity is due to the successful development and transfer of knowledge and technology to the industry, thereby achieving competitive advantage worldwide. In essence, universities serve as a channel to exchange knowledge and technology more effectively (Mascarenhas et al., 2018).

Recently, the Covid-19 pandemics provoked huge negative impacts worldwide. Many businesses had to close and it seems that some companies are not prepared to handle this crisis. While others like internet-based businesses and service industries related to takeout, cleaning products, healthcare and medication, as well as, herbs and vitamins have thrived (Donthu & Gustafsson, 2020). This pandemic situation has also generated opportunities for start-ups through the exploration of new products, markets, and value propositions (Reuschke, Mason, & Syrett, 2021). Covid-19 has also accelerated the digitalization process (Khan,

Niazi, Nasir, Hussain, & Khan, 2021; Nurhayati et al., 2021) and affected the existing supply chain for some markets (Reuschke et al., 2021).

The following research questions will guide the research and help explore addressing critical problems related to science commercialization in times of covid.

1.2 Project's objectives

The main objective of this study is to explore science and technology commercialization success factors and challenges of start-ups in times of covid-19. The following research questions will be addressed to achieve this goal:

- **RQ1:** What are the main ways to start a new venture?
- **RQ2:** What are the main partnerships that start-ups have with universities?
- **RQ3:** What are the success factors of the commercialization of start-ups?
- **RQ4:** What are the challenges and limitations of commercialization?
- **RQ5:** What is the impact of COVID-19 on start-ups?

1.3 Report outline

This report is organized into seven chapters as follows:

Chapter 1 introduces this dissertation's context and objectives.

Chapter 2 covers the literature review. It provides an overview of start-up creation, academic knowledge, the commercialization process, and the impact of COVID-19 on firms.

Chapter 3 shows the methodology employed in this study.

Chapter 4 presents the main results from this study, covering information about start-up's creation, commercialization process, covid-19 impacts, and start-up expected future.

Chapter 5 follows the result's discussion.

Chapter 6 highlights the conclusions and contributions, as well as, the limitations and insights for future works.

2 Literature Review

This chapter discusses the state-of-the-art in the relevant areas of the project. The objective is to understand what is known and the existing gaps in the literature that could be explored. This step is crucial to address the research questions afterward. Firstly, it provides an overview of what is known about start-ups' creation. Secondly, it covers key topics and concepts related to academic knowledge-transfer and the commercialization process. Finally, it presents an overview of covid-19 impacts on new ventures.

2.1 Start-ups' Creation

The process of creating and developing a new venture is complex and challenging, which can include many competencies needed to turn scientific findings into marketable products or services in order to gain a competitive advantage (Fini, Rasmussen, et al., 2020; Rasmussen, Mosey, & Wright, 2014). The creation of a start-up is a process that starts with a venture idea or opportunity, followed by an entrepreneurial intention of getting the idea off the drawing board through preparatory actions involving resource mobilization, competence creation, and activities organization using the entrepreneur networks to create value for the company (Reuschke et al., 2021; Salamzadeh & Kirby, 2017). According to Reymen et al. (2015), this whole process is marked by the need to decide and take action in an uncertain environment. The nature and outcome of the discoveries, and the commercialization process itself, aside from being risk, is unpredictable. This uncertainty makes it more difficult for the entrepreneur to organize the emerging venture. In this sense, entrepreneurs should develop their skills in planning and adapting, compete and collaborate, and calculate expected returns and limit downside loss (Reymen et al., 2015). However, according to Shim and Davidsson (2018), the new venture creation process is not a long journey that needs to get through many challenges. Actually, in many cases, the new venture generates profit in the first months or is dissipated within the first year, frequently without significant financial losses, and usually has a longer duration than those who obtained success. Shim and Davidsson (2018) also show that through a few actions, new ventures can be profitable in a moment, even though this is not true for all kinds of firms like innovation-based biotech.

Spiegel et al. (2016) state that the business model developed in the early-stage phase changes quickly and substantially. In this sense, a business model is a description of an organization and how it functions in order to achieve its goals in terms of profitability, growth, social impact, among others (Massa, Tucci, & Afuah, 2017). Its dimensions are: value proposition (type of service and strategy of differentiation), value creation (key activities, key resources, and company processes), value delivery (target customer and communication), and value capture (revenue model and cost structure). (Mikl, Herold, Ćwiklicki, & Kummer, 2020; Tallman, Luo, & Buckley, 2018)

Regarding the motivations to create a new venture, Ferreira, Loiola, and Gondim (2017) say that developing personal management skills is the highest motivation among all surveyed college students, followed by social/ sustainability and financial motivations. Gundolf, Gast, and Géraudel (2017), however, found out that one of the founder's motivations is the independence that the creation of a start-up provides. Besides that, Ferreira et al. (2017) show that the students are eager to put their managerial skills into practice that requires many skills in strategy, accounting, finance, legal and technical expertise essential in running the

business. It also indicates that the difference between university entrepreneurs and experienced ones is related to motivation and business plans. Ferreira et al. (2017) also highlight the idealization of potential entrepreneurs, also known as university students. They choose opportunities based on intuition and novelty. Opposite to experienced entrepreneurs who have already dealt with business management problems and know how to overcome the challenges and thus focus more on financial success factors and less on new ideas and products for seeing them as non-manageable risks (Ferreira et al., 2017). The entrepreneurs might realize novel ideas take longer to launch, though they usually will continue trying for as long as their confidence in the opportunity stays high. The novelty might prolong process time and further increase the risk of not making a profit, as a longer duration might be associated with a lesser chance of success (Shim & Davidsson, 2018).

Some factors that enhance academic entrepreneurship and can help start-ups creation include: Peer effects, especially the presence of role models (Huyghe & Knockaert, 2015; Perkmann, Salandra, Tartari, McKelvey, & Hughes, 2021); universities' policies, regulations, and culture that can support the engagement in spin-off creation; intellectual property rights and industry-science interaction (Fini, Grimaldi, et al., 2020; Huyghe & Knockaert, 2015); reward system that not only value scientific output, but also include entrepreneurial activities (Huyghe & Knockaert, 2015); innovation at least for the chosen market; the solution must have the potential to be replicated at large scale (Martínez & Crusat, 2019). On the other hand, challenges of academic entrepreneurship are: (1) *Individual level challenges* (lack of resources for combining different roles; the mixture of roles and activities; absence of entrepreneurial role model); (2) *Institutional level challenges* (lack of legitimacy and incentives; lack of institutional support; and entrepreneurial skills development; uncertainty in university role for society); and (3) *Regional level challenges* (regional industry development: geographical proximity and clusters presence; policy-related issues) (Miller, Alexander, Cunningham, & Albats, 2018).

2.2 Academic Knowledge-Transfer

Universities have always been known for their function of teaching and research. However, in recent years, they have been suffering pressure to shift their operation to add a third mission, that is contribution to society. Universities engaged in third mission activities are contributing to the social, economic, and cultural development of the regions in which they handle, by transferring knowledge and technologies to organizations and society in general, through promoting entrepreneurial skills, innovation, human capital, and use of technology and infrastructure (Compagnucci & Spigarelli, 2020; Perkmann et al., 2021). The third mission is a complex and evolving phenomenon that has been stimulated by universities, industry, government, and society (Compagnucci & Spigarelli, 2020). It has led to an increase in university-industry interactions through policy actions aimed to promote science commercialization (Bodas Freitas, Geuna, & Rossi, 2013; Rybníček & Königsgruber, 2019).

Miranda, Chamorro, and Rubio (2018) state that universities are required to be more business-oriented, commercializing the outcome of their scientific discovery and encourage university spin-off creation. Also, the term spin-off is related to the process and result of creating a company from another pre-existing organization. The university spin-off refers to the exploitation of new processes, products, or services driving from the knowledge obtained in the university. These spin-offs contribute to the generation of businesses, jobs creation, positive impact on the economic system, and positive influence in innovative processes

(Miranda et al., 2018). On the other hand, according to Rasmussen et al. (2014) spin-off creation is more challenging and time-consuming than the disclosure of scientific discovery. Another fundamental point is the challenge to commercialize an invention given the traditional non-commercial environment from universities different from a company (Rasmussen et al., 2014). Hence, Siegel and Wright (2015) claim academic entrepreneurship is created to provide a social and economic benefit, as well as, democratize access to the university ecosystem. Rippa and Secundo (2019) explain that it can also generate spin-offs, aid students and alumni through start-up creation, contribute to entrepreneurship education, and help with innovation and regional development like job creation in the local region. This can be done through accelerators, collaborative networks with industry, incubators, experimental labs, and more (Rippa & Secundo, 2019; Siegel & Wright, 2015).

Clayton et al. (2018) explain that incubators and accelerators might be connected to universities or operate as a public, non-profit, or organization based on profit. *Incubators* are usually for new venture creation and idea development where they support early-stage firms to the point of becoming viable organizations (Clayton et al., 2018). They frequently bring young companies together at the same workspace at an affordable price, provide support services, and generate revenue for the incumbent companies (Jon Eckhardt, 2015). They support their operation by receiving rent for the right to use the incubator facility (Clayton et al., 2018; Jon Eckhardt, 2015). As for university incubators, they usually translate academic findings into innovations. However, they might compete with other university programs that involve innovation and generate revenue (e.g., patents) (Kolympiris & Klein, 2017). The most crucial factors involved in the university incubators' success are human resources, technology, financial and organizational resources (Mavi, Gheibdoust, Khanfar, & Mavi, 2019). On the other hand, Clayton et al. (2018) say *Accelerators* provide financing and other services to entrepreneurs who are creating or developing start-up companies. They differ from incubators on the duration of the program, business model, intense mentorship and education about entrepreneurship, coworking space, networks, among an infinity of other relationships that can exist between the new venture and the accelerator like direct investment, support with funding, and partnership, for example, to produce a pilot. Jon Eckhardt (2015) claim that accelerators also highlight finding the value proposition for the client, which is beneficial for scientists-entrepreneurs who usually focus on the scientific features of the business. After an intense 10 to 12 weeks program, entrepreneurs should be able to know the viability of the project. Even if the science behind the product or service is strong, it is not a good opportunity if there is no market (Jon Eckhardt, 2015). Accelerators are similar to venture capitalists as they invest in a group of firms, expecting to receive great returns from a few ones (Clayton et al., 2018; Jon Eckhardt, 2015).

As for university accelerators, more and more universities are establishing such organizations to support student entrepreneurship. The main services used by the start-ups are assistance in obtaining funding, drafting business plans, and product development (Breznitz & Zhang, 2019).

According to van Stijn, van Rijnsoever, and van Veelen (2018) other university-start-up interactions could be: *Entrepreneurship case studies* where the entrepreneurs are invited into the university classroom to talk about real business problems; *Engineering and scientific case studies* related to the education provided by universities and start-ups; *Hiring graduates* refers to act of hiring graduated students by start-ups; *Product development courses* are university courses that aim to solve real problems and build a marketable product with students from different backgrounds; *Entrepreneurship courses* are university courses that focus on

developing a business; *Internships* refers to the participation of students in start-ups through an internship; *Competitions* related to universities organizing the participation of start-ups in business competitions; *Mentoring services* provided by universities in order to help start-ups development; *Collaborative research* refers to researchers done in collaboration between universities and start-ups; *Academic consulting* when the university provide advice and expertise to start-ups; *Donating* resources between universities and start-ups; *Licensing* related to the protection and commercialization of intellectual property originated from academic research; and *Piloting* where the university provides a pilot site or niche market to test the start-up product or service.

In this context, University-Industry collaboration is considered a crucial driver of innovation, production, and economic growth, as it facilitates the commercialization of scientific knowledge within companies (de Wit-de Vries, Dolfsma, van der Windt, & Gerkema, 2019; Fini, Grimaldi, et al., 2020). Some studies argue that collaboration with universities per se does not guarantee an enhancement in innovation capabilities. They say that it is necessary to have an absorptive capacity that enables companies to exploit new knowledge and opportunities (Najafi-Tavani, Najafi-Tavani, Naudé, Oghazi, & Zeynaloo, 2018; Rajalo & Vadi, 2017). On the other hand, Libaers (2017) claims too much collaboration with industry is hurtful to the commercialization, as the collaboration will enable speedy learning, but the overlap in knowledge domain among academic and private sector scientists will become too similar to lead to radical innovation. Overall, University-Industry cooperation has different motives, perspectives, several barriers, and facilitating factors, as such university-industry collaborations are multifaceted (Rajalo & Vadi, 2017).

2.3 Commercialization process

Science commercialization is the process of transferring an invention (science discovery) from the creator of the technology to an organization, thus creating a marketable product/service, known as innovation. Successful science commercialization depends on innovation type and the risk run with the commercialization and cooperation between organizations (Haeussler & Assmus, 2021; Kirchberger & Pohl, 2016). Hence, innovation is recognized as an important factor in creating value and sustaining competitive advantage (Mascarenhas et al., 2018; Rowley, Baregheh, & Sambrook, 2011). Forsman (2011) defines innovation capacity as a constant improvement of the resources and the ability to deploy them (capabilities) to explore opportunities for developing new products and services to meet market needs. Mascarenhas et al. (2018) say that successful innovation is related to R&D contracts, suppliers, customers, and competitors. According to Y. Kim and Lui (2015), it can improve knowledge, access to new markets, lower costs of production and R&D.

In fact, according to Biemans and Griffin (2018) successful companies usually have a solid commitment to innovation and allocate a significant number of resources to these innovation efforts. However, there are differences between the innovation processes of manufactures and new service companies. These differences are related to the characteristics of services: intangibility, simultaneity, heterogeneity, perishability, and co-production with customers. Thus, Biemans and Griffin (2018) suggest that R&D investments are more strongly associated with manufacturing than service innovation. Moreover, R&D activities in manufacture are a requirement for incremental and radical innovation, while for services, R&D activities are less common and linked to radical new service development (Biemans & Griffin, 2018), but this may be because service innovation often involves informal R&D tasks like experimentation,

learning, evaluation of technologies which are difficult to measure, and may take a long lead time, unlike formal R&D activities (Forsman, 2011; Miller et al., 2018). In this sense, companies have to create profit by creating new values and attain competitive advantage through innovation and science commercialization capabilities while providing new product and service development through R&D investment and quality improvement (J. H. Kim, Seok, Choi, Jung, & Yu, 2020). In this context, one way to classify the organizations is as *Manufacture companies* that focus on offering products or *Service-dominant firms* that focus on service offerings (Johansson, Raddats, & Witell, 2019). Another way to classify may be as *B2B* (business to business) related to a business conducted exclusively between organizations, or *B2C* (Business to Consumer) as a business conducted between a company and end-user consumers (Biemans & Griffin, 2018).

Much of the knowledge discovered by researchers is hard to commercialize immediately and must be translated, understood, and have a specific market opportunity to be useful to companies (Reymen et al., 2015; Zahra et al., 2018). Most of the knowledge developed might never achieve commercialization due to being unable to find a marketable opportunity, poor fit with the company business definition, weak appropriability, or lack of resources (Fini, Rasmussen, et al., 2020; Zahra et al., 2018). Other challenges of the start-ups that can affect the commercialization process are: lack of experience of the founders, lack of strategy related to Identifying and recruiting talents, vague hierarchies, unclear scaling plan, overestimating market demand, and communication problems (Pandey & Pattnaik, 2017). Additionally, protection of intellectual property, fast development, and useful product or service are factors more important than novelty itself for the success of science commercialization (J. Eckhardt & Wetherbe, 2016; Fini, Rasmussen, et al., 2020).

According to Mason, Friesl, and Ford (2019) the valuation practices for successful commercialization of a product/service are performed through actions between science (impact of intellectual property ownership; scientific work data), market (scope, scale, competition, market), and entrepreneurship (business model). Besides that, J. H. Kim et al. (2020) state that technology commercialization capabilities have an impact on sustainable competitive advantage. This means that technology commercialization is a crucial success factor for survival in the ever-changing market environment. This capability can ensure that the right technology is available in the market, increase the product life cycles, have a continuous ideas and product development. Furthermore, quality management activities have great impacts on sustainable competitive advantages, which means, that factors such as pricing and delivery reliability affect the competitive advantage (J. H. Kim et al., 2020). Another crucial point for success is the founder's network, as the founders' network provides information and resources to develop the business model in the early stages. (Spiegel et al., 2016)

For a successful start, entrepreneurs must have: a uniquely superior product; understand the dimension of the market (if it is attractive to the customers, and that larger markets can attract bigger companies as competitors, therefore the niche markets can be more interesting in the first years of the start-up); the return on investment expected in time and money, and the necessary effort needed to develop and launch the opportunity found; initial strategy focused on innovation to have a course of actions to maximizes the success (Cooper, 2019; Pareras, 2021). In this sense, timing is a crucial factor, as opportunities exist only during a short time and unless the business acts fast, it will disappear. In other words, new technologies, changes in policies and regulations, and changes in customer behavior can create opportunities, but the window of opportunity should be used as fast as possible. For this fast development,

entrepreneurial initiatives should be focused on environments where there has been fast growth and innovation culture, for example, the sectors with a strong scientific and technological component (Pareras, 2021).

Tallman et al. (2018) claim the future will likely have a faster, less predictable, more competitive and global, ambiguous, and riskier market. Consequently, the need for a more agile, adaptative, and flexible new product process will only grow and those firms primarily seeking to reduce their time to market might look to tools for leaning down the system (Cooper, 2017).

2.4 COVID-19 impacts

Socio-economics impacts

Cullen, Gulati, and Kelly (2020) claim that it is a common occurrence the emotional distress and social disorder during outbreaks. Despite that, psychological and psychiatric needs are often not attended to, and resources applied are not enough to manage the pandemic's effects on mental health and wellbeing. In this context, the impacts of covid-19 and the policies of lockdown and quarantine generate several psychological impacts, such as the increase in anxiety and depressive symptoms, as well as, some people experiencing post-traumatic stress disorder that should be considered and treated as soon as possible (Cullen et al., 2020). Some studies conclude that the fear of economic crisis and unemployment can impact mental health and cause stress, depression, and anxiety during the Covid-19 outbreak (Khan et al., 2021; Reuschke et al., 2021). On the other hand, the use of digital technologies can keep people connected and may help reduce the harmful effects of the pandemic (Donthu & Gustafsson, 2020). It can also provide the employees with training and keep them up to date with advanced knowledge might help with the fear of unemployment (Khan et al., 2021).

Innovation Opportunities

Innovation will play a key role in the economic recovery process after Covid-19. The process of creating innovation is often considered burdensome and expensive, in which anything is decided upon which approach costs less (Chesbrough, 2020). However, in a pandemic situation, time is more valuable and the cost factor is less important than the ability to get a solution earlier (Nurhayati et al., 2021). In other words, innovation is considered a source of competitive advantage and for many industries, it became a matter of survival in the current period. In the end, this crisis has forced the development of open innovation in many industries (Khan et al., 2021).

Donthu and Gustafsson (2020) state that due to the covid-19 pandemic, in the future, some countries may become more nationalistic and less globalized. This is something dangerous, as to overcome the pandemic outbreak is likely to require global effort and sharing resources and knowledge, as well as, global cooperation is the key to deal with other global challenges that appear in the future (Donthu & Gustafsson, 2020). Open innovation can help speed up the entire innovation process and optimally integrating new ideas to face the competition and improve performance. For example, many powerful new technologies do not have an obvious way to create a value proposition (AI, IoT, or blockchain) and the best way to find attractive business uses is to experiment in a wide variety of different ways (Chesbrough, 2020). Hence, practicing more openness in science and technology can be worth the attention as the solutions to complex problems often come from non-conventional sources, for example, user

innovation (Nurhayati et al., 2021). For Teplov, Albats, and Podmetina (2019), open innovation means that a company is progressively using external knowledge to accelerate its internal innovation process. Davoudi et al. (2018) explain that companies should use external and internal ideas to enhance their technology. In other words, they should explore many internal and external sources of innovation, integrating that exploration with their capabilities and resources, and exploit the opportunities. Overall, open innovation focuses on coming up with new ideas, reducing risks, and accelerating the innovation process which is needed in Covid-19 times (Davoudi et al., 2018; Teplov et al., 2019).

According to Davoudi et al. (2018), intellectual property rights or patents are one of the most important factors of open innovation. Furthermore, it seems that organizational performance is not directly connected with intellectual property rights. However, open innovation has a positive impact on organizational performance. Therefore, intellectual property rights will indirectly affect performance positively through open innovation. Chesbrough (2020) says the covid-19 pandemic is stimulating innovation about the management of intellectual property rights. For instance, some initiatives are employed to encourage firms and universities to release some of their patents in the fight against covid-19. In this unstable moment, opening up access to intellectual property might unlock new prospects with suppliers, clients, partners, and universities. As many patents are neither used nor licensed, this is a good time to invest in open innovation instead of being wasteful.

Some studies stated that the participation of the government through the implementation of technical standards and policies that overcome the impact of the pandemic and control the spread of Covid-19 are now high priorities and one of the factors that can reduce stock trading volatility (Hu & Zhang, 2021; Nurhayati et al., 2021). Furthermore, according to Chesbrough (2020) in a pandemic, the regulatory environment, as everything else, needs to adapt. In times of covid-19, regulators also need to be more open. Transparency offers society protection against shady offerings, and in these times of crisis, shared regulatory studies are essential to speed up the process. In this sense, society should be willing to accept higher risk to have faster development and production of critical equipment, vaccines, and diagnostics, during this period. (Chesbrough, 2020)

Impact on the market

The coronavirus crisis has affected the existing supply chain for some markets, challenged traditional business models, and affected the future of small businesses during lockdowns occurring around the world (Reuschke et al., 2021). However, Donthu and Gustafsson (2020) show that, during this covid-19 crisis, while some businesses are struggling, others are flourishing. It explains that important industries like the automobile, transports and electronics have closed, at least for a short time, and it seems that some companies are not prepared to handle this crisis. It seems they cannot adapt and think of alternative sources of income. The pandemic might cause fluctuation in demand for specific products, which can make the estimation of demand more difficult now than ever, and an urgent issue to address. On the other hand, for internet-based businesses, such as e-commerce and solutions for remote work, the demand has increased as everyone had to stay at home during the lockdown and quarantine period. Other industries like takeout, cleaning products, healthcare, medication, herbs, and vitamins are also doing well. The changes in the consumer's behavior during this epidemic increased the demand for snacks, alcohol, takeout, and the focus on health and hygiene (Donthu & Gustafsson, 2020). This situation has also generated

opportunities for small businesses, for example, through the exploration of new products, and supply sources (Reuschke et al., 2021).

Donthu and Gustafsson (2020) foresee that in the future, the clients will prefer less in-person interaction which will lead to investments in technology, as a necessity for engaging customers and the well-being of the employees. Nurhayati et al. (2021) claim that it will also accelerate the digitalization process to increase effectiveness, market penetration, and introduce new services and innovations with a digital channel. Besides the digitalization process, many companies focus on social and environmental sustainability to reimagine and redesign their offering (Donthu & Gustafsson, 2020; Nurhayati et al., 2021). This aspect of sustainability is so important that on 25 September 2015 the United Nations set seventeen sustainable development goals (see Figure 1) that have specific targets to be accomplished by 2030. This new sustainable development agenda has the goal of eradicating poverty, protecting the planet, and ensure prosperity for all (United Nations, 2016).



Figure 1 - United Nations Sustainable development goals

Moreover, Reuschke et al. (2021) explain that the covid-19 pandemic has modified the use of digital technologies for the future of traditional businesses, entrepreneurship, and local economies, which, in turn, raises questions about the future of cities and the importance of physical proximity. Reuschke et al. (2021) also claim that before the covid-19 pandemic, the big cities dominated entrepreneurship and innovation. Now remote working enables companies to hire employees around the world as they are not restricted to work in one specific location. It also can impact the small business with one-person, home-based, or that had remote works. This kind of business can shift away from high costs ecosystems to smaller hubs without losing talented people. This situation could lead to the weakening of big cities' ecosystems and economic growth in smaller cities (Reuschke et al., 2021).

3 Methodology

The methodology applied in this study is qualitative research using exploratory in-depth interviews with start-ups actors (Harrison, Birks, Franklin, & Mills, 2017). In-depth interviewing is a form of qualitative approach that conducts a small number of individual interviews to explore the respondent's perspective over a specific issue or situation. This approach can help researchers to explore the science commercialization issues and others factors related to start-ups. In the end, the in-depth interview will provide a deeper meaning to the extracted data (Adhabi & Anozie, 2017; Boyce & Neale, 2006).

This chapter aims to explain the methodological approach chosen to address the research questions. Firstly, it analyzes the different approaches and defends the methodology used in the dissertation project. Followed by the description of the method used, the different steps, and procedures.

3.1 Comparative analysis of existing approaches

According to Gehman et al. (2018) in order to select the best approach to use in a research it is important to have a clear theoretical goal and to create a methodological fit where the methodological tools are suited to the research goal.

Quantitative methodology generally is based on surveys, experiments, and statistical methods in order to test the hypotheses. This approach is usually favored for being considered more rigorous than qualitative approaches (Harrison et al., 2017; Ridder, 2017).

Design Science Research is a method that brings practical relevance, with its emphasis on useful artifacts, and scientific rigor, with the formulation of design theories. In this context, design science research contributes to the research world by providing useful solutions and unique inputs to knowledge (Baskerville, Baiyere, Gregor, Hevner, & Rossi, 2018).

Finally, qualitative methodology approaches the world from a different perspective. It does not seek to measure anything, instead it usually has an exploratory aim (Dodgson, 2017). Mason et al. (2019) claim that qualitative methodology suits the science commercialization study since it is a dynamic process and has a coordinated practice of multiple actors. Hence, in order to explore science commercialization issues, it is more adequate to use a qualitative approach.

3.2 Sample criteria and selection

As a qualitative study the sample is non-probability. Eighteen start-up founders from two incubators, UPTEC from the University of Porto or UACOOPERA from the University of Aveiro, were selected. The sample was selected to cover start-ups in different sectors and maturity stages to ensure a rich diversity of perspectives. Due to confidentiality agreements, the names of the interviewees and the start-ups are excluded from this report.

Table 1 shows the characteristics of the eighteen start-ups and Table 2 shows relevant information about the co-founders. A more complete description of the characteristics of the start-ups can be found in Table 13 and Table 14 in Appendix B.

Table 1 – Sample characteristics (N = 18)

Category	Item	Number
Firm Industry	Electrical system devices	1
	Sensor	1
	Medical devices	1
	Tracking devices	1
	Biotechnology	1
	Textile	1
	Financial Service	1
	Information Technology consulting	5
	Cleaning Service	1
	IOT solutions	1
	Agricultural solutions	1
	Transportation and mobility solutions	1
	Smart building solutions	1
	Water networks solutions	1
Firm establishment period	up to 2 years ago	4
	from 3 to 6 years ago	10
	from 7 to 12 years ago	4
Programs participated¹	Incubation	16
	University spin-off	8
	Acceleration	6
Firm Size	Up to 5 employees	5
	6 to 22 employees	11
	40 to 180 employees	2
Sales Amount per year in Euros	Less than 40 thousand	2
	200 thousand to 300 thousand	4
	1 million to 2 million	4
	Not answered	8

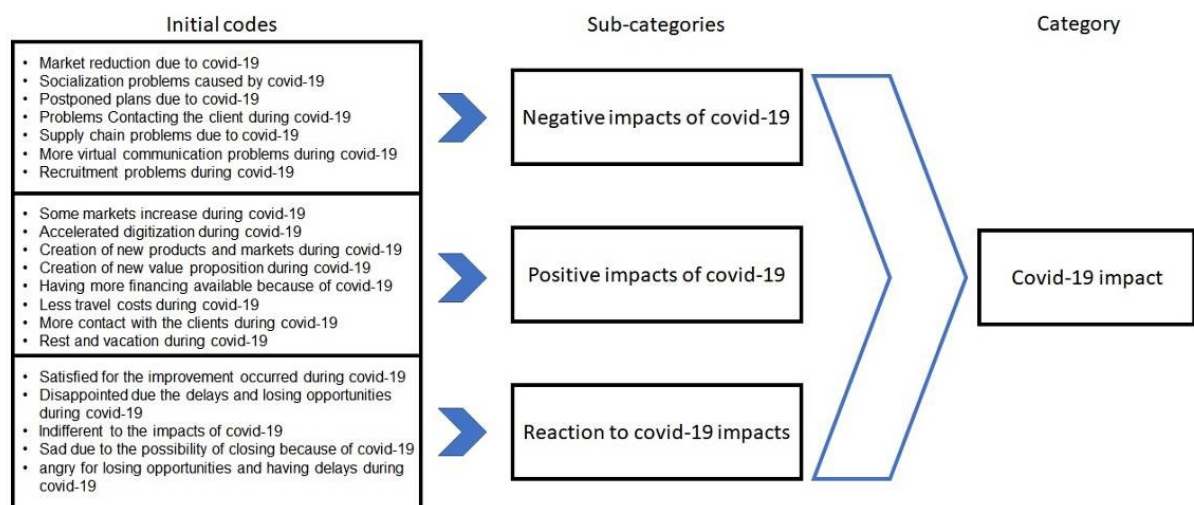
¹ Some start-ups participated in more than one program, as such, the sum is more than 18.

Table 2 - General characteristics of the co-founders (N = 18)

Category	Item	Number
Gender	Male	16
	Female	2
Number of co-founders in the start-up	1 co-founder	3
	2 co-founders	5
	3 co-founders	5
	4 co-founders	4
	5 co-founders	1
Co-founders background	Engineering	9
	Engineering and design	2
	Engineering and management	3
	Management	2
	Science – Biotechnology	1
	International Relations	1
Education Level	Bachelor's degree	3
	Master's degree	11
	Doctoral degree	4
Co-founders experience	Have business experience	8
	Without previous experience	10

3.3 Data Collection and Analysis

As the most preferred qualitative data collection is the semi-structured in-depth interview (Adhabi & Anozie, 2017), the data was collected through recorded interviews. Eighteen semi-structured interviews, lasting an average of 27 minutes each were conducted. Due to covid-19, data collection was done online via google meets platform, in April and May 2021. The script guiding the interviews is included in Appendix A. The recordings were verbatim transcribed and data analyzed using qualitative data analysis software, NVIVO. Following the procedures recommended by Saldaña (2021) the analysis of the interviews started with breaking down the data into smaller units and attributing codes to them, based on the research questions. By analyzing each one of the interviews a few times and comparing concepts, it was possible to figure out common patterns and gradually assemble the initial codes into more abstract, conceptual categories, as shown in Figure 2.

**Figure 2 - Example of the Categorization Process**

4 Results

This chapter describes the results of the analysis of the 18 in-depth interviews with start-up's co-founders, with emphasis on the main aspects of science commercialization like success factors and challenges, as well as, motivations and how they position themselves in the market. Other aspects that will be highlighted are the discoveries about incubation and partnerships with universities, as well as, impacts and reactions to covid-19 on the start-ups. Finally, it will show the expected future of the start-ups.

4.1 Start-up beginning and academic knowledge

This section will explore data results about new venture beginning and partnerships with universities.

Starting a new venture

The results show that the key ways to start a new venture are:

- being university entrepreneur;
- start a company as a family project;
- had clients before as a freelancer and believe it would be a good opportunity to create a start-up;
- or being an experienced entrepreneur with great business experience.

Regarding the firm maturation time which is the time between the idea creation until the establishment of the new venture that varies from less than six months until four years (See table 14 in Appendix B). The data analysis shows that this time is mostly related to the incubation time for idea consolidation, searching for financing, and researching and testing the new technology before effectively establishing the company. It is important to understand the incubation experience and other forms of partnership with universities. One participant even said: "As we are from the scientific area and engineers and scientists, mentoring in the business area is always important, at the beginning it was new and, therefore, we learned a lot in these acceleration and entrepreneurship programs. Also, the connection to the incubator and the university provides some support and training in these areas." (male, start-up founder, medical devices industry)

Partnerships with universities

Regarding the accelerator programs, this study did not deeply explore this theme. To better understand the start-ups' motivations regarding their participation in accelerator programs, some testimonials of participants are following presented.

[We spent] one month in an accelerator that helped us understand how to make the business plan. In the end, it was good for us to test out some ideas, but when it came time to do it, we had to learn it all over again, but the ideas were there. (male, start-up founder, tracking devices industry)

On the business side, we started the acceleration program in Porto, which was promoted by the national association of young entrepreneurs. It was a relatively simple and short-lived program for a few months (2-3 months). We had some training and presented the project and we were selected and won the award and had a connection with investors and got some initial investment. (male, start-up founder, medical devices industry)

For the incubation experience, the co-founders said that the benefits are: helping to connect with other start-ups and creating networking; creating opportunities for start-ups in terms of clients and financing; mentoring and training programs; providing workspace; exploring and adapting the initial idea; and having specialized services for start-ups like legal support and communication service. On the other hand, some start-ups co-founders mentioned that they did not have a good experience with incubation. What some of them said was:

When we were going to [the incubator], we caught a transition within [the incubator] itself where they were changing direction, philosophy, people [...] That was not exactly an incubator. (male, start-up founder, transportation and mobility solution industry)

We have been incubated [...] since the beginning in a virtual form [...] Being very honest about our relationship with [the incubator], we were never physically present. So, I cannot say that being incubated was crucial, it was not. [...] Especially because it is an area that is not as glamorous as some start-ups. It is also not an area of much interest, even for those who are strong in technology. (male, start-up founder, cleaning outsourcing industry)

Other than incubation, some co-founders said they had other partnerships with universities, such as: research and development collaboration; talent access and recruitment through the universities; partnerships for internships and dissertation development; coaching and training obtained through universities; and university spin-off experience.

For the university spin-off experience, the co-founders explained that it could help the start-up with financing, and consolidating the idea. However, other start-ups mentioned that being a university spin-off might take away their independence. What one of them said was:

One of the things we wanted was to be 100% independent. We did not want to be a spin-off from a university, we wanted to be independent. And having control of the intellectual property of our product [...] For example, when we started to develop this idea in our heads, we were Ph.D. students, [but] if I used the university equipment [...] What was my part in this prototype? The idea was mine, but the one who invested even without knowing what it was investing in was the university. (female, start-up founder, biotechnology industry)

4.2 Commercialization process

This section will explore the commercialization issues related to start-up positioning, success factors, and challenges. According to Table 14 in Appendix B, the firm commercialization period ranges from less than two years until eleven years, and some start-ups are not even in the commercialization phase. This shows that there are different commercialization phases on the selected sample which can provide a diversified overview of commercialization issues.

Start-up positioning

Start-up positioning refers to how the start-up position themselves in the market, as so, it will explore information about target market, competition, and value proposition.

Target Market

Regarding the target market (see Table 3), the results show that: usually the start-ups operate on B2B and a few on B2C; some of them works on a niche market; some of them had international clients scattered around the world, but especially in Europe; and others did not have a target market defined from the beginning.

Table 3 - Market information

Category	Item	%
Geographic Market²	Europe	61%
	North America	39%
	South America	33%
	Only Portugal	28%
	Other Markets	28%
	Not answered	11%
International Market Sales	0%	44%
	10% to 50%	17%
	90% to 97%	11%
	100%	6%
	Not in the commercialization phase	11%
	Not answered	11%
Market³	Niche Market	61%
	Other type of market	39%
	Target market defined from the beginning	72%
	Target market initially undefined	28%
	B2B	94%
	B2C	17%

In this context, when questioned about the market research conducted (see Table 4) the founders said that they usually look for target market, competitors, technological alternatives, partners and suppliers. The majority prefers to do the research internally instead of hiring a company, a few have not done any market research, because they already knew the market to some extent. A few said that the market research is important and is continuously done inside the organization, while others said that what they did was depthless research without much to add to the project.

² The start-ups can be interested in more than one region, as such, the sum is more than 100%.

³ Some firms work in B2B and B2C, as such, the sum is more than 100%.

Table 4 - Market research information

Category	Item	%
How the research was done	Done Internally	61%
	Hired a company	11%
	Not done	22%
	Not answered	6%
Other information	Research continuously done	22%
	Depthless research	11%
Methods to get data⁴	Searched in social networking and websites	39%
	Had Interviews and meetings	33%
	Looked in the database	22%
	Used Events and conference	11%
	Not answered	39%
Research about⁵	Target market	72%
	Competition	61%
	Technological Alternatives	33%
	Partners and supplier	17%

Value proposition

The results show that the main value propositions of the start-ups interviewees are: integration with the client; having the ability to reduce client's costs; having a customization-based offering; having a support decision making offering; focus on innovation; solutions through new technology; having a complementary service offering; having an automatization offering; focus on design; focus on sustainability. Importantly, out of the seventeen sustainable development goals, only seven were mentioned in this study: zero hunger; clear water and sanitation; affordable and clean energy; decent work and economic growth; industry, innovation and infrastructure; responsible consumption and production; life below water. And as one of the founders said: "From the moment that the final customer awareness about these sustainability issues [grow], whether concerning animals or ecological, all this awareness starts growing in people. Therefore, it is a market that is expanding". (female, start-up founder, biotechnology industry)

Competition

The results of the main competitors of the start-ups and their definition according to the founders are summarized below in Table 5.

⁴ Some start-ups use several ways to collect data for market research, as such, the sum is more than 100%.

⁵The start-ups can search more than one topic when doing market research, as such, the sum is more than 100%.

Table 5 - Analysis of the start-ups' competitors

Competitors	Definitions and quotes
	<i>Definition 1:</i> as an indirect competitor, some start-ups do not have the strength to compete directly with them. "So, any consulting company that works in this area are our competitors and that's obviously the place of [big] consultants [...] it is not a direct occurrence, but an indirect competition." (male, start-up founder, financial service industry)
Big players	<i>Definition 2:</i> when the start-up is innovative enough to compete directly with the big players that are using the old paradigm. "We compete with large companies, larger than ourselves and even some well-known multinationals [...] What differentiates us from them is the approach in terms of process, as they are very stagnant companies in terms of innovation." (male, start-up founder, cleaning outsourcing industry)
Start-ups	<i>Definition:</i> Other start-ups with similar approaches. "Our competitors are very similar to us [...] [they] are start-ups like us. They are companies with 11 to 30 employees, they are recent companies with 3 to 7 years in the market." (male, start-up founder, information technology consulting industry)
International Competitors	<i>Definition:</i> when the start-up targets international markets or when the other international companies are targeting Portugal market. "[We know the competition] whether it is from Portugal [...]. As well as international companies, because the market is now global." (male, start-up founder, information technology consulting industry)
Informal Market	<i>Definition:</i> It delivers a similar product or service, but without tax and labor obligations. "We had this limitation because the informal economy in Portugal is very expressive [for this sector]. Therefore, we are unable to practice the prices that are practiced in this economy, because VAT alone is 23%. [...] The fact that everything is formal, employment contract, everything up to date, social security, all of this brings us to an incomparable price." (male, start-up founder, cleaning outsourcing industry)
Supplier and competitor	<i>Definition:</i> this happens when the start-up has a supplier who can directly supply the final customer. "This is an unstable situation, because Google is often our competitor that is more dangerous than the others because it is also our supplier." (male, start-up founder, transportation and mobility solution industry)

Success factors of commercialization

The data analysis shows that for the co-founders the success factors of commercialization are: having the ability to attract and maintain the clients (e.g. provide good service quality; get referrals; make a commitment and build trust and credibility with customers; offer an attractive price for the clients, which means the start-ups can deliver value for money in terms of the benefits obtained; and have good retention of the customers); having talents in the company; having market knowledge which could help with product-market-fit and the best timing for launching; having financing access; having good networking; being part of an incubator or spin-off can deliver value for the start-up as described on the topic about the partnerships with universities; having scalability which means the ability to replicate the product or service at large scale; having patents and intellectual protection; good internal and external communication; and having management skills. For examples of success factors, see Table 6.

Table 6 - Success factors of commercialization

Success factors	Quotes
Ability to attract and maintain the clients	"[The success factors are related to] two moments: the moment of the purchase and then the moment of retention. [...] For the purchase it is mainly price and commercial arguments." (male, start-up founder, agricultural solution industry) "[The success factor is] the degree of commitment you make to your customer. The more committed you are with your customer, [...] the greater the success rate of selling and being able to commercialize." (male, start-up founder, electrical system industry) "[One success factor] is having a great quality of service offering. So, the customer can trust in our service/product and can place more orders." (male, start-up founder, sensor industry) "In the end, it all comes down to the value we can deliver versus the cost." (male, start-up founder, tracking devices industry)
Talents	"The initial success factor was having talent, that is, having people available at a much more competitive price." (male, start-up founder, financial service industry)
Management skills	"The way we manage [the company] [...] makes all the difference." (male, start-up founder, cleaning outsourcing industry)
Market knowledge	"[One success factor is] the need to adapt the product to what the market wants [...] to have a distinctive factor. [The other one is] The definition of pricing, something that is accepted in the market and at the same time sustainable for the company." (male, start-up founder, agricultural solution industry) "[One factor of success is to] have well-defined target Market profiles. Realize the personas we have, whom we want to sell to. [...] And see if we can adapt to what the market asks for." (male, start-up founder, information technology consulting industry) "I have been working with the insurance industry for 25 years before opening this company. During this professional journey, I identified a set of needs within the insurance company, and I saw an opportunity there to act." (male, start-up founder, information technology consulting industry)
Financing access	"Financial without any doubts [is a factor of success]. Without initial financial resources it would be impossible." (male, start-up founder, agricultural solution industry)
Networking	"The networking also helps and is very important, because you need to know the right people and customers." (male, start-up founder, medical devices industry)
Being part of an incubator or spin-off	"One of the selling points we had was the fact that we were able to enter [this] incubator" (male, start-up founder, financial service industry) "Being a university spin-off helped us in the beginning." (male, start-up founder, tracking devices industry)
Scalability	"[One factor of success is] to go from concept proof to large scale." (male, start-up founder, electrical system industry)
Patents and intellectual protection	"Intellectual property is one of the most important resources we have" (male, start-up founder, IOT solution industry) "Intellectual property is critical because without it we cannot move forward." (female, start-up founder, biotechnology industry)
Good communication	"Communication is an essential [factor for the success]." (female, start-up founder, biotechnology industry)

When questioned about the main stakeholders, the majority of the co-founders identified clients and investors. Other stakeholders are partners and suppliers, employees, co-founders, universities, and the Government. This is in line with what has been discovered about the success factors and importance of clients, investments, employees, and universities. A founder's further explanation about clients and investment can be found below:

I believe that any product to be successful has to create value. In other words, our product has to be able to generate value for the customer and it has to be able to generate value for us. If it does not create value for the customer, it is not salable and if it does not create value for us, it will not be sustainable. So, I would say that this is the most important. [...] From the moment we start thinking of developing this [technology], we thought that there is a potential here. We have to think about what we are going to do. Are we going to do it with our money or are we going to the bank to get a loan? [...] we want to do something sustainable or we are going to get more into the start-up area and we are going to speed it up. [Then] Let's look for venture capital grants. From the moment we seek venture capital, we will make investment rounds to accelerate even more, and then the objective is to return on investors. (male, start-up founder, sensor industry)

Regarding funding access that is one of the factors of success reported by the founders. Table 7 shows that the financing amount ranges from 10 thousand to 30 million depending on the industry. The main financing sources reported are: self-funded or having other investors, receiving monetary awards, and granting and funding. The founders also stressed the importance of financing and some explained the importance of capital venture:

Money is the most critical resource, because money allows you to capture talent and ability and because that is what people focus on. (male, start-up founder, transportation and mobility solution industry)

Often the big challenge is financial because an organization needs to survive. In other words, having its own capacity to generate value and that is challenging. It is the big challenge. (male, start-up founder, information technology consulting industry)

The biggest limitation in biotechnology is funding, from the beginning when we were still thinking about the idea as students, it is funding. (female, start-up founder, biotechnology industry)

In Portugal, there are lots of Venture Capitals that started in the last 3-4 years with a lot of money that has driven the creation of new companies with digital products. (male, start-up founder, information technology consulting industry)

Start-ups usually resort to venture capital and investment funds, venture capital, etc. (male, start-up founder, cleaning outsourcing industry)

Table 7 - Financing information

Category	Item	%
Financing Amount	10 thousand	6%
	100 thousand to 250 thousand	28%
	300 thousand to 600 thousand	22%
	1 million to 2 million	17%
	30 million	6%
	Not answered	22%
Financing Sources ⁶	<i>Investors</i>	
	Angel Investors	6%
	Private companies	33%
	Venture capital	22%
	Self-founded	33%
	<i>Award Financing⁷</i>	
	National Awards	33%
	International awards	17%
	<i>Grants and funding</i>	
	European Funding	17%
	Portugal Funding	17%

Regarding the importance of market knowledge, the results of the marketing strategies implemented (see Table 8) are that the majority of the start-ups in this study used a direct sale and just a few use some kind of distributors which is in line with the fact that most of the start-ups chosen in this study sell services and thus distributors are not a necessity. For the monetization strategy, it is used pay-per-use, subscription, and buy the product. Finally, in the communication channel, they use the digital channel more than other channels, like websites for its low cost, but can use events and conferences, and word-of-mouth to advertise their service and product. Also, for a company that is starting and does not have visibility, most of them use a trial and pilot strategy to test their technology, which facilitates the sales process and increases their credibility with the customers. For example:

We are constantly testing our products with partners and customers. It is also part of our sales process to do trial and customer testing, we constantly try to demonstrate our product to the customer with pilots and trials. We are constantly in the process of gathering feedback and adapting based on that. (male, start-up founder, IOT solution industry)

⁶ The start-ups can have more than one financing source, and as such, the sum is more than 100%.

⁷ The same start-up could have the national and the international awards.

Table 8 - Marketing Strategy

Category	Item	%
Sales Channel	Direct	83%
	Distributors	17%
Monetization⁸	Pay-per-use	44%
	Subscription	39%
	Buy the product	28%
Communication Channel⁹	<i>Digital channel</i>	0%
	Website	33%
	Other Digital channels	11%
	<i>Other Channels</i>	0%
	Events and conferences	17%
	Word-of-mouth	17%
	Other channels	11%
	Not answered	44%
Other strategies	Used trial and pilot's strategy	61%

Challenges and limitations of science commercialization

The results show that for the co-founders the limitations and challenges of commercialization are: not having enough financing resources; lack of trust from the clients and being an unknown brand; management and bureaucracy problems; scalability issues that are problems to replicate the product at a large scale; not having enough market knowledge that might affect the product-market-fit (product or service that does not satisfy the market demand) and the best timing for launching the product; difficult access to talents; communication problems; and geography problems (the place where the start-up is born can be a limitation for its growth). The data analysis also shows that for the co-founders the best way to overcome these challenges is: having flexibility, agility and adaptability; hard work to convince and support the clients; trial and error method; creating and improving the existing technology; having help from networking, especially tips from other start-ups which have gone through similar problems; working the brand awareness; coaching and training related to fields that they are not strong (e.g. management); understanding the strengths and weakness to overcome the problems. For a more complete description of the challenges and how the start-ups overcome them see Table 9.

⁸ Some companies use more than one kind of monetization, as such, the sum is more than 100%.

⁹ Some companies use more than one kind of communication channel, as such, the sum is more than 100%.

Table 9 - Main challenges of the commercialization

Challenges	Quotes	How to overcome the challenges	
Not enough financing resources	"Without private investment it is very complicated, because we are developing a technology and we need a lot of funds just for development." (male, start-up founder, tracking devices industry)	Convince and support the clients; Working the brand visibility	Know your strength and weakness
Lack of trust from the clients and being an unknown brand	"It is difficult to create a brand and make it visible in the first years. It is always a great effort to have an opportunity." (male, start-up founder, cleaning outsourcing industry) "Our clients [...] do not like to trust in [...] a small start-up as they do not know if in a year we will be here. So, there is all the prior work of credibility and commitment to get their trust, that is fundamental in this area." (male, start-up founder, information technology consulting industry)		
Management problems and bureaucracy	"Therefore, the difficulty was [...] management in general." (male, start-up founder, financial service industry) "Many requests began to appear, bureaucracy, fiscal, financial, accounting, so it was a hindrance in the beginning." (male, start-up founder, electrical system industry)	Coaching and Training	Help from Networking;
Scalability problems	"We have a challenge in terms of technological research that has to do with putting technologies that are not being used on a large scale." (male, start-up founder, information technology consulting industry)	Create and improve the technology	Trial and error method;
Not enough market knowledge	"We focused a lot on the technological part, as engineers do. We built the technology and we did not care so much about the market. What happened was that we built the technology and when we came to the market and were doing the tests, we still had to change a lot to adapt to the need [of the market]." (male, start-up founder, tracking devices industry) "One of the main difficulties is that we often know the need will exist, but we are sooner than [the actual need and] the customers have difficult to absorb [this new solution]." (male, start-up founder, IOT solution industry)		
Difficult access to talents	"It is difficult for us [...] to have a good recruitment process, [...] to be able to choose people well." (male, start-up founder, information technology consulting industry)	Flexibility, agility and adaptability;	Flexibility, agility and adaptability;
Communication problems	"The biggest problem is communication. Problems to communicate with customers [...] It is a huge difficulty to be able to adapt and transmit what we want to these different cultures and even internal communication [is complicated]." (male, start-up founder, information technology consulting industry)		
Geography problems	"It is not the same as being a Start-up in Portugal or being a start-up in Silicon Valley, because first, they have more mature markets, they are more developed, they have much more purchasing power, more investment and therefore geography is an essential aspect." (male, start-up founder, transportation and mobility solution industry)		

4.3 Covid-19 impacts for start-ups

In this section the impacts (positive and negative) of the covid-19 pandemic, as well as, the co-founder reactions are explored. Results showed that the co-founder reactions to these impacts were: satisfaction with the improvement of the start-up during the covid-19 crisis; disappointment or anger due to the delays and losing opportunities during this period; sadness due to the possibility of closing the start-up; and for some the impacts of covid-19 are not important. For example, the start-ups that did not feel an impact from the pandemic state that:

The proof of this is that with an event like COVID we had customers who had products that depend on physical contact that disappeared completely and [...] we also had customers who increased a lot and the company ended up increasing the team. So, on a financial level, we did not have a big impact. In fact, I would even say that it was the same as before [covid-19 crisis]. (male, start-up founder, information technology consulting industry)

Positive impacts

The data analysis unfolded some positive impacts of the covid-19 pandemic, in the perspective of the co-founders: Increased sales for some markets; accelerated digitization; opportunity to create new products and new markets; opportunity to create new value proposition adjusted to new times; having more financing available; less travel costs as a result of the restrictions and quarantine periods; more contact with the clients through virtual meetings imposed by social distance measures; and having a period of rest and vacation during quarantine. For a more complete description of the reactions of the co-founders and the covid-19 positive impacts on the start-ups see Table 10.

Negative impacts

The data analysis also revealed some negatives impacts of the covid-19 pandemic for the co-founders: sales decreasing in some markets; socialization problems; postponed plans related to sales and technology development; difficulties in contacting clients physically due to social distance measures; supply chain problems and delays to deliver the products; communication problems related to virtual communication that causes some misunderstandings; and recruitment problems due to international competition. For a more complete description of the reactions of the co-founders and the covid-19 negative impacts on the start-ups see Table 11.

4.4 Start-up expected future

In general, the founders could foresee the following future scenarios for their start-ups in the next five to ten years: expand the current offer and market; become global and internationally recognized; create new markets and products; improve and advance the technology used; sell the company; end of the company or specific product; join a bigger company; stay as it is nowadays.

Table 10 - Covid-19 positive impacts on Start-ups

Impacts	Definitions and quotes	General reaction: Satisfaction
Increased sales for some markets	<i>Definition:</i> Some markets had an increase in sales during the covid-19 crisis. “Other [markets] prospered. All that were pulses and citrus. It was all fruits and vegetables that were much in demand during the pandemic to maintain resistance. People were looking for defenses. Therefore, soups and similar continued to exist. This type of customer thrived during the pandemic.” (male, start-up founder, agricultural solution industry)	
Accelerated digitization	<i>Definition:</i> Covid-19 crisis has helped in accelerating the digitization process. “What I have noticed is that there has been a huge boom in information technology. Because of COVID, digitalization has accelerated a lot.” (male, start-up founder, information technology consulting industry)	
Create new products and markets	<i>Definition:</i> Opportunity to create a new products and markets during the covid-19 period. “It allowed us to focus on other faster and more agile industries and we were able to more quickly bring the software to market.” (male, start-up founder, IOT solution industry) “There was a positive impact, we had to launch a new product [during the covid-19 crisis]” (male, start-up founder, textile industry)	Possibility of sales increase
Create new value proposition	<i>Definition:</i> Opportunity to create new value proposition adaptable to covid-19 times. “That is why the [covid-19 crisis] has made the need to use systems or software or tools that make buildings more flexible and manage to overcome this challenge of fluctuating occupancy more urgent.” (female, start-up founder, smart building solution industry)	
More contact with the clients	<i>Definition:</i> More contact with the clients through virtual meetings during the covid-19 period. “People accepted more meetings with us for commercial actions, or for the presentation or realization of our products virtually.” (male, start-up founder, information technology consulting industry)	
More financing available	<i>Definition:</i> Having more financing available because of covid-19 funding. “Last year, during the pandemic, we had support from the state, a program that we applied called COVID 19 productive innovation.” (male, start-up founder, cleaning outsourcing industry) “This investment from Portugal Ventures that we ended up winning was what allowed us to start. It was an investment developed exactly to help start-ups in the context of COVID.” (female, start-up founder, biotechnology industry)	More funding available
Less travel costs	<i>Definition:</i> Less travel costs as a result of the restrictions during the covid-19 period and impossibility to travel “We used to make a lot of trips [...] and all that was now greatly minimized. This also translates into gains for the company and we managed to have the same level of efficiency.” (male, start-up founder, information technology consulting industry)	Cost reduction
Rest and vacation	<i>Definition:</i> Rest and vacation during quarantine “During the March-April confinement, I could rest my head, as we had been running for 1 year, unable to breathe, I could rest, I could put some ideas on paper that were only in my head.” (male, start-up founder, textile industry)	More time to rest

Table 11 - Covid-19 negative impacts on Start-ups

Impacts	Definitions and quotes	General reaction: Disappointment or anger
Sales decreasing in some markets	<i>Definition:</i> Due to the covid-19 crisis, there was a reduction in sales for some markets. “The first sales are critical for a start-up and no one predicts that there will be a pandemic that takes 70 percent of the market” (male, start-up founder, transportation and mobility solution industry)	
Contacting physically the client is more difficult	<i>Definition:</i> Due to the fact that physical contact is restricted, some companies reported that they had difficulties in contacting customers physically and that virtual means were not enough. “Anything involving commercial travel and presentation was completely suspended. [...] We attended these conferences and did some online presentations, but [...] We did not get the same feedback we would get at a conference and a physical encounter.” (male, start-up founder, medical devices industry)	Lost opportunities
Socialization problems	<i>Definition:</i> Due to the quarantine period, people were not physically at their workplaces and this affected the socialization of employees which is valuable by the companies. “We value and think the issue of social contact is very important, the social aspect of people getting to know each other, people talking and interacting is relevant.” (male, start-up founder, information technology consulting industry) “Therefore, the impact that we had, in reality, was that we did not have this socialization, we have a very unique culture, very familiar, we are very close. [...] Covid came to end this. All this socialization died.” (male, start-up founder, information technology consulting industry)	Lost of socialization
Postponed plans	<i>Definition:</i> The start-ups had to postpone technology development plans, or contracts that were to be signed were postponed due to the current unstable situation. “The pandemic has delayed the automobile industry's programs in the development and introduction of new technologies.” (male, start-up founder, IOT solution industry) “[The problem] is decisions standby. In other words, we had clients who were about to decide to move forward and ended up restricting investments due to a lack of knowledge of the future. [...] Therefore, the impact was not so much a reduction in sales directly, or in customers. It was the delay of these customers.” (male, start-up founder, agricultural solution industry)	Delays in plans
Supply chain problems	<i>Definition:</i> Some start-ups had delays from suppliers and consequently embarrassment with customers who expected the product. “For one month the factory was closed [...] Customers ended up understanding at the time that there was no chance of delivering [the product] and that it was a global health issue.” (male, start-up founder, textile industry)	
Communication problems	<i>Definition:</i> Due to the covid-19 crisis, virtual communication is more available, but sometimes it does not allow us to see people's reactions and this can cause misunderstandings. “The facial expression, the body expression disappeared with COVID.” (male, start-up founder, information technology consulting industry)	Communication problems
Recruitment problems	<i>Definition:</i> In this pandemic, international companies were looking for Portuguese professionals and hampered the recruitment process for Portuguese companies “With COVID, companies realized that they had to work remotely, and [...] it no longer makes sense to hire in your geographic area, which means that companies in North America and Central Europe started looking at Portugal as a good talent base at a lower price.” (male, start-up founder, information technology consulting industry)	Recruitment problems

5 Discussion

This chapter will present the discussion of the results, considering the research questions and the literature review.

5.1 Start-up beginning

Regarding the main paths for new ventures creation, the results of this study explore other types of entrepreneurs besides university entrepreneurs and experienced ones, for example, ones that originated from family projects. As such, this study expands the work of Ferreira et al. (2017) that points out only the difference between university students' entrepreneurs and experienced ones. The first choose opportunities based on intuition and novelty while the latter focus on financial success factors rather than novelty and have more facility to overcome challenges through experience.

The results also show that the main programs the start-up participate in are: incubation, acceleration, university spin-off, and other partnerships with universities, which is in line with what is known about academic entrepreneurship and its programs (Rippa & Secundo, 2019; Siegel & Wright, 2015).

The study results about incubation experience are consistent with previous studies. For example, Clayton et al. (2018) say that the incubators help with idea development, networking between peers (other start-ups), provide specialized services, workspace, create opportunities for new ventures, among other benefits. Regarding the workspace of the incubators, the majority of the founders interviewed state that this service is affordable and they could use it for as long as they wanted. There were also a few companies who said they were not incubated, as they only used a few functionalities of the incubators, such as, the workspace. In this context, the firm incubated time (see Table 14 in Appendix B) ranges from less than one year until twelve years. This long time is due to some founders that could not say when it stopped being a typical incubator and started to work only as a workspace. Another point is that some start-ups that did not come from universities with glamorous ideas have reported not having a good experience with the university incubator, which might mean that university incubators focus more on university entrepreneurs. As such, this study expands the work of Kolympiris and Klein (2017) that point out that university incubators regularly transform academic findings into commercially useful innovations.

This research did not extensively explore the accelerator experience. Hence, what is collected is about how a short-lived experience (1 to 3 months), helps to understand how to make a business plan and get connections with investors, which can help to get an initial investment. These results show the basic information displayed in previous studies about accelerators (Clayton et al., 2018; Jon Eckhardt, 2015).

Miranda et al. (2018) say university spin-off refers to the exploitation of novelty through the knowledge obtained in the university itself. In this sense, the results of our study show that being a university helps consolidate the idea and obtaining financing. On the other hand, results showed that for some founders being a spin-off may take away their independence. This may happen because one of the motivations to create a start-up is the independence that it provides for the co-founders (Gundolf et al. 2017).

The results showed that other partnerships with universities can be: research and development, talent access and recruitment, internships and dissertation development; coaching and training which is consistent with previous studies (van Stijn et al., 2018).

5.2 Commercialization process

Regarding the start-ups business model, the results of our study explore especially the dimensions of value delivery (target customer and communication) and value proposition (Mikl et al., 2020; Tallman et al., 2018).

Regarding the target market or value delivery, the results of our study show that some start-ups work in a niche market, as the larger markets can attract bigger companies as competitors, which could be tricky for new ventures (Pareras, 2021). This study goes further and explains that in niche markets is easier to understand the market movements. Also, having a small scale makes it easier to start operating and competing. This can be seen in the testimonials of some founders:

We are still operating in this niche, and it is very easy for us to follow market movements and as everyone knows each other. (male, start-up founder, financial service industry)

It is the only [target] in which we can compete financially. At that moment, with the costs we have with: production, optimization, and research, we are not able to compete with others, not even in logistical terms. (female, start-up founder, biotechnology industry)

As the world is more competitive and global (Tallman et al., 2018) it makes sense that the target market of the start-ups in this study includes international clients and that the start-ups also face international competition. Regarding the international competition, the results identified two types: one when the company competes on the international market and the other one, when the new venture focuses only on Portugal and has to compete with multinationals. This study has also done some advancements concerning the competition analysis by identifying the main actors that compete with start-ups.

For a successful start, entrepreneurs need to understand the market and for that is to integrate with the client, focus on innovation and design, as well as, on complementary services (Cooper, 2019; Pareras, 2021). Moreover, the focus on sustainability is important (Donthu & Gustafsson, 2020; Nurhayati et al., 2021). The results not only show the importance of these factors to add value for the client, but also adds information about the importance of the sustainable development goals to help to sell the product. One of the founders said: “The desire of some companies to understand how this decarbonization issue works and how to be more efficient and more sustainable. All of this has helped us to sell our product.” (male, start-up founder, water networks solution industry)

In a pandemic situation, time is more valuable, and the cost factor is less important than the ability to get a solution earlier (Chesbrough, 2020; Nurhayati et al., 2021). However, the results suggest that the focus of the companies is actually on reducing costs. Some founders said:

Given that the priority of the banks now and in business in general is to cut costs (male, start-up founder, financial service industry)

It was complicated, because early last year, many companies, including the car industry, lowered production. And even all innovation projects no longer have the relevance they normally have, they were the last priority. With that, we had a period when it was difficult for us to convince them to test our product when they did not have a budget to idealize this type of project. (male, start-up founder, tracking devices industry)

Success factors of commercialization

Shim and Davidsson (2018) claim that in many cases the new venture is profitable in the first months. However, for some industries, like innovation-based biotech that is not possible. The results of our study go beyond and show that apparently the financial performance expectation can also influence the need for funding. As some start-ups know that it will take a long time to break even in a specific market, such as the biotechnology sector, they will need more investment. On the other hand, if they have a good financial performance from the beginning, just a self-found investment might be enough to break even.

The results about the factors of commercialization success are similar to previous studies such as: the ones related to the customers and the knowledge of the market (Cooper, 2019; Pareras, 2021), intellectual property rights or patents (Davoudi et al., 2018; Fini, Rasmussen, et al., 2020), fast development related to the window of opportunity (best timing to launch the product), the quality of the product or service (J. Eckhardt & Wetherbe, 2016; Fini, Rasmussen, et al., 2020), product-market fit (J. H. Kim et al., 2020), access to investments privates and publics (Pareras, 2021; Szücs, 2018), having managerial skills (Ferreira et al., 2017; J. H. Kim et al., 2020), founder's network (Spiegel et al., 2016), the importance of business models that are the strength of the incubators and accelerators programs (Mason et al., 2019), pricing (J. H. Kim et al., 2020), and scalability (Martínez & Crusat, 2019).

The limitations and challenges faced during the process of commercialization

This study's results about limitations and challenges of start-ups are also consistent with previous investigations. The main limitations are the difficulties to have access to resources like investments and talents, as well as, the need to reduce the time to market to not lose the window of opportunity (best timing to launch the product) (Cooper, 2017; Shim & Davidsson, 2018). Other challenges and limitations might include the inability to find a marketable opportunity with a good product-market fit, and problems related to communication (Fini, Rasmussen, et al., 2020; Zahra et al., 2018), lack of strategy related to identifying and recruiting talents, and unclear scaling plan (Pandey & Pattnaik, 2017). Another known challenge is the bureaucracy related to accounting, finance, legal, among others that can be stressful (Ferreira et al., 2017) especially for the university entrepreneur without experience which is something that the results of our study have shown.

As shown in Table 12, the firm time to market ranges from less than one year until six years, and it shows that for some industries, especially those related to service, the time to market can be really short, while for others can take a while, especially those that need to develop the technology, like medical devices. In this context, some industries could have a long time to market to develop the technology or get the necessary investment which could disrupt their timing for the launch. For example:

They are funding to start the idea, to start the prototype. It is big money we are talking about here. And we, as co-founders, could not start without investment. (female, start-up founder, biotechnology industry)

So, if we can be faster, we could in a year. If there was financing available faster. What delayed was the speed of capital. (male, start-up founder, electrical system devices industry)

Partnerships with universities and co-financed projects allowed us to accelerate. In addition to private investment. (male, start-up founder, medical devices industry)

The risk factor is often the start-ups have identified an opportunity very well, they know how to develop an optimal solution to solve it, but external factors or because they were unable to get the investment in time or because they did not find the sufficient amount, it will take longer to develop it than expected and when they finally launched it there was already another one occupying the place. Timing for me is the most important factor. (male, start-up founder, transportation and mobility solution industry)

Table 12 - Analysis of time to market

Industry	Time to market	up to 1 year	from 1,5 year to 3 years	from 4 years to 6 years	Not in the commercialization phase
Textile		1			
Financial Service		1			
Cleaning Service		1			
Agricultural solutions		1			
Information Technology consulting		4	1		
Tracking devices			1		
Transportation and mobility solutions			1		
Smart building solutions			1		
Water networks solutions			1		
Electrical system devices				1	
Medical devices				1	
IOT solutions				1	
Sensor					1
Biotechnology					1

Start-ups, for example, in this pandemic moment, can shift away from high costs ecosystems to smaller hubs without losing talented people (Reuschke et al., 2021). However, the results show that in this moment of crisis and remote work is more difficult to hire talents.

The flexibility, agility, and adaptability of the start-ups have always been noticed (Cooper, 2017). So, it makes sense to use this ability to overcome the challenges. Furthermore, during a pandemic situation, one of the ways to overcome the problems is through partnerships and networking (Davoudi et al., 2018; Teplov et al., 2019). Moreover, results also showed that most of the challenges related to management and market knowledge refer to start-ups with university founders which might indicate that experienced entrepreneurs have the ability to overcome some challenges.

5.3 Covid-19 impacts

Some positive impacts of covid-19 presented in this study are also reported on previous studies: increased sales for some internet-based businesses (e.g. e-commerce, and solutions for remote work, takeout, cleaning products, healthcare, and medication) (Donthu & Gustafsson, 2020). This pandemic situation has also generated opportunities for start-ups through the exploration of new products, markets, and value propositions (Reuschke et al., 2021).

Covid-19 has accelerated the digitalization process that can be translated into new opportunities created with digital channels (Khan et al., 2021; Nurhayati et al., 2021) and the use of digital technologies, such as online services or information-sharing platforms, which can keep people connected (Donthu & Gustafsson, 2020). Some co-founders even reported that they could have more contact with the clients through virtual meetings during covid-19 restrictions. Another important point is that having an automatization offering as a value proposition as reported in our study could probably help on this process of digitalization. Regarding the use of a digital channel, some participants already used it as a communication channel before and so this might be the reason why some start-ups did not feel the strong negative impact of the covid-19 pandemic. Moreover, the results show that the nature of the start-ups with flexibility, agility, and adaptability has probably helped them overcome the challenges, even in a pandemic situation.

Some negative impacts presented in this study are in line with previous studies showing the reduction of sales in some markets, at least for a short time, and some companies are not well prepared to handle this crisis (Donthu & Gustafsson, 2020). In terms of impact on the market, the coronavirus crisis has affected the existing supply chain for some markets (Reuschke et al., 2021). Other important extant research showed emotional distress and social disorder during outbreaks, such as covid-19. In this context, the effects of covid-19 and the policies of lockdown and quarantine generate many psychological impacts, such as the increase in anxiety and depressive symptoms which can affect socialization (Cullen et al., 2020) and some studies conclude that the fear of economic crisis and unemployment can impact the mental health and cause stress, depression, and anxiety during Covid-19 outbreak (Khan et al., 2021; Reuschke et al., 2021). However, the results show that at least for the co-founders in the sample, the covid-19 provoked a mix of emotions, such as: satisfaction with the improvement of the start-up during the covid-19 crisis; disappointment or anger due to the delays and losing opportunities during this period; sadness due to the possibility of closing the start-up; and for some the impacts of covid-19 is not important.

In the future, because of covid-19, the digitalization process will be accelerated and there will be an improvement on current technologies used (Khan et al., 2021; Nurhayati et al., 2021). As well as, some companies will thrive while others will perish (Donthu & Gustafsson, 2020). Even in a normal situation, these scenarios are expected to happen, but with covid-19 the complexity increases, as shown in this study.

6 Conclusion

This chapter provides the main conclusions drawn by the dissertation that answers the research questions formulated in Chapter 1.2. It also highlights the future researches and limitations of this study.

6.1 Project conclusions

This dissertation focused on exploring the science commercialization success factors, limitations, and challenges of start-ups in times of covid-19 getting an overview from the beginning until the expected future. To address the RQ1, initial analysis has shown that there are other types of motivations to start a new venture besides being a university students' entrepreneur and experienced ones, like project family or those who started as a freelancer. Other points that contribute to the literature are related to the market research conducted, where most of the founders start their research, and where they look mainly for target market and competitors. Regarding the target market, some start-ups did not have a target market defined from the beginning while others choose a niche market. This study contributes to further exploration of why the start-ups choose niche markets. On the other hand, this study has also done some advancements concerning the competition analysis by identifying the main actors that compete with start-ups.

To answer RQ2 this study has identified the main partnerships that start-ups have with universities. It contributes to the literature with the fact that some start-ups believe the great advantage of the incubators is the affordable workspace that can maintain their relationships for years or can even be the only relationship between the start-up and the incubator. Another interesting discovery is that some founders believe that being a spin-off might take away their independence and why they think so.

Regarding the success factors of science commercialization that address the RQ3, this study has similar results from previous studies. However, this study has contributed with: a contrast between financial performance expectation and the need for funding; the importance of the use of a digital channel to not feel the strong negative impact of the covid-19 pandemic; the importance of the use of a trial and pilot strategy to test the technology, which facilitates the sales process and increases their credibility with the customers.

To answer RQ4 this study has identified the main challenges and limitations. It contributes to the literature with information about how the start-ups overcome the challenges and that some industries could have a long time to market to develop the technology or get the necessary investment which could disrupt their timing for the launch of the product or service.

Regarding the covid-19 impacts on new ventures that address the RQ5, this study is a first step in investigating the impacts of covid-19 on new ventures. Besides all the impacts (positive or negative) of covid-19, it is important to highlight other points, like the fact that this study has shown that in this period the focus of the companies is not on innovation, but on how to reduce costs, contrary to other studies. Also, as the Covid-19 has accelerated the digitalization process, having an automatization offering as a value proposition could probably help in this process of digitalization. Another important point is that even though this study has identified socialization problems, it did not find any significant impacts related to emotional distress and social disorder related to the covid-19 outbreak.

6.2 Future research and limitations

Despite the great body of literature on the field of science commercialization, there are still few studies aiming to explore this theme in the light of the covid-19 crisis. In this context, it is important to deepen this knowledge using longitudinal research, since it reflects business trends, whose knowledge and understanding become almost mandatory for any organization that wishes to ensure any competitive advantage in the market in the next years after covid-19. The main strength of the qualitative approach used in this study lies in the depth of the results enabling the exploration of the underlying aspects. This approach can help researchers to explore the science commercialization issues during and after covid-19 and others factors related to start-ups. However, like any study this one also has limitations. The sample is limited and a qualitative approach was used, which limits the generalizability of the conclusions of this study. Another point is that most studies about science commercialization are from the UK and the US and the Portuguese reality is different in terms of market, universities, and innovation.

For future studies, it would be interesting to understand how the following aspects might impact start-ups' development: the different kinds of co-founder's motivations found in this study; the possibility of the university incubator focusing more on university entrepreneurs and workspace service. Furthermore, sustainability is critical, thus studies should explore the importance of sustainable development goals for the competitive advantage of the companies, and explore the competition analysis of the start-ups, in order to understand how this can impact the markets or national policies in the case of informal market, for example. Moreover, covid-19 impacts in new ventures need to be explored to fully understand the consequences and necessary actions to overcome the difficulties and take advantage of novel opportunities. Furthermore, additional qualitative studies can be used to deepen the understanding of some conclusions from this study. For example, a suggestion would be to explore more the themes like accelerator programs and spin-offs that were not so deeply explored in this research. Finally, it would be interesting to have more quantitative studies that adopt a comparative approach to the results of this research in terms of other industries, in developed and developing countries, among other factors.

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APPENDIX A: Interview Guidelines

1. What is the company sector? (e.g., energy, finances, construction, education)
2. When was the company founded, incubated, and launched in the market?
3. How many co-founders and their characteristics? (e.g., background/experience)
4. What is the size of the company in terms of employees?
 - a. How is the organizational structure of the company? (e.g., departments)
5. What are the main stakeholders? (e.g., investors, mentors)
6. How did the project start, and what generated the initial idea?
 - a. Was there collaboration with research institutes and universities? How was the collaboration and what did it generate? (e.g., science, technology, Support to R&D)
7. What form of financing/programs/rewards did the company use? And what is the amount of investment required?
8. Describe the product/ service that you are offering
9. What are the target market and opportunities?
 - a. Describe the company value proposition to the market
 - b. Describe the market competition. (Are there critical competitors?)
 - c. In your opinion, how long will this trend last in the market?
10. In your opinion, what are the success factors of commercialization?
 - a. In your opinion, what were the critical resources for the commercialization?
 - b. What were the limitations and challenges you faced during the process of commercialization? How did you get over it?
 - c. What is the impact of Covid-19 pandemic crisis on the company/project's activity (e.g. sales in domestic/international market, labour activity, allocation of resources, relationship with customers/suppliers)
11. Describe the commercialization process
 - a. Has the company done any market research? How was it done?
 - b. How is the customer integrated into the service/product development process? Is it related to open innovation?
 - c. Have you tested the product / done a usability test? And how was it done?
 - d. Is the product/service available in the market? Since when and what is the sales amount (volume)? National and International market in %.
 - e. How long does it take for the product/ service to be available to the market? (i.e., time to market)
 - f. Has the company used any specific method or process to speed up the commercialization process? (e.g., patents, partnerships, licensing) How did it work?
12. How do you see your company in the future, 5 or 10 years?

APPENDIX B: Socio-demographic Data

Table 13 - Characteristics of the start-ups (N=18)

Category	Item	Number
Firm Sector and Industry	<i>Technology</i>	
	Electrical system devices	1
	Sensor	1
	Medical devices	1
	Tracking devices	1
	Biotechnology	1
	Textile	1
	<i>Consulting and Outsourcing</i>	
	Financial Service	1
	Information Technology	5
	Cleaning Service	1
	<i>Other Services</i>	
	IOT solutions	1
	Agricultural solutions	1
	Transportation and mobility solutions	1
	Smart building solutions	1
	Water networks solutions	1
Firm Size	Up to 5 employees	5
	6 to 10 employees	5
	11 to 22 employees	6
	40 to 180 employees	2
Sales Amount per year	18 thousand to 200 thousand products	2
	6 to 15 projects	2
	Less than 40 thousand	2
	200 thousand to 300 thousand	4
	1 million to 2 million	4
	Not answered	4

Table 14 – Firms' key time indicators (N=18)

Category	Item	Number
Firm establishment period	up to 2 years	4
	from 3 to 6 years	10
	from 7 to 9 years	3
	up to 12 years	1
Firm Commercialization period	up to 2 years	8
	from 3 to 6 years	7
	up to 11 years	1
	Not in the commercialization phase	2
Firm Time to Market	up to 1 year	8
	from 1,5 years to 3 years	5
	from 4 years to 6 years	3
	Not in the commercialization phase	2
Firm Incubated time	up to 1 year incubated	3
	from 2 to 3 years incubated	6
	from 4 to 7 years incubated	5
	up to 12 years incubated	1
	Not answered	1
	Not incubated	2
Firm Maturation time	Less than 6 months to establish the company	12
	up to 6 months to establish the company	3
	up to 1 year to establish the company	2
	up to 4 years to establish the company	1

