The private and the public game: a focus on the innovation processes inside the U.S. space sector

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Abstract

This research explores the innovation process inside the US Space sector. It does it by inquiring about the economic and social partnership that is taking place between the private sector, taking part in the industry under the form of commercial companies, and the government that participates in the sector under the form of research organizations and state institutions such as NASA and the Department of Defense. Research shows that the space industry has a low presence of financial institutions such as banks, making it an interesting case to study the interaction and dialogue between the private and the state regarding innovation. After an introduction, chapter 1 presents the research question. The research question addresses the innovation processes inside the US space sector. To better investigate, the research question is broken down into five sub-questions, each based on a core element of investigation of the research, respectively: (i) motivation; (ii) strategy; (iii) competition; (iv) organization; and (v) funding; the chapter continues by presenting the conceptual and analytical framework that the research follows. Chapter 2 summarizes the current views of the innovation process with investments. Chapter 3 is a literature review on the state of the art of the US Space sector from an economic perspective. The research uses both quantitative and qualitative analysis to explore the topic. Therefore, Chapter 4 describes the thesis's operationalization, while chapter 5 presents the main results from the two studies. Chapter 6 is the conclusion chapter. The research makes conclusions and answers by adopting a triangulation methodology between the quantitative, the qualitative, and the literature review. Triangulation is used as a methodology because it can better capture the complex aspect of real-world phenomena as the innovation process inside the space industry. To conclude, in the same chapter, policy recommendations and reflections on the work are made.

Introduction

The subject of study of this thesis is the innovation process. In the context of this research, innovation is the result of the interaction of the different stakeholders that are part of the economic landscape. Therefore, the thesis takes a step backward compared to the engineering and technological perspective of innovation, and it looks at innovation by inquiring about hidden and fewer material relations. The economic sector of interest that the research studies is the US space sector. The unique conditions of the space industry are the reason for the choice. It is a relevant small industry compared to the US national economy; nevertheless, because of the condition in which it operates, it requires high levels of technological development. Because of the amount of complexity and trans-sectoral knowledge required, together with the social impact of its development, space is a grand societal challenge (Cagnin et al., 2012). A relevant characteristic of the sector is the low presence of financial institutions as investors. Financial institutions usually are understood as risk-averse (Angelini, 2000); therefore, they limit innovation exploration due to the uncertainty that is associated with these activities in terms of revenues and success (Mazzucato, 2013). These conditions describe space as an interesting case to study innovation processes from a less material perspective. Given the low presence of financial actors, private agents, and government institutions are the two main groups participating in the sector. Different goals and values drive the two groups, but the interaction between these two groups creates the innovation processes. Therefore, this thesis can reveal internal processes that lead to innovation activities between the private and the public sectors. The interaction between these actors leads to the manifestation of innovation inside the production of new technologies given on an engineering and technical level. The thesis first frames the US space sector under the business ecosystem concept (Peltoniemi & Vuori, 2004).

The conceptualization draws ten selected elements and their relations within the ecosystem, making them the object of study. The ten elements (e.g., competition, organization, motivation) share the commonality of being difficult to quantify due to their internal characteristic. However, by understanding them is possible to highlight the less tangible relations present in the business ecosystem, revealing important considerations between the private and public organizations and the relations that these social parts of the economy have with innovation. Therefore, the finding of this research situates themselves in a more extensive discussion between economic perspective and innovation. The classical neoliberal economic views suggest that having high levels of innovation in a sector is better than having less state participation (Clarke, 2005). This is because private companies are generally more efficient in the innovative process by having a significant degree of freedom and creativity. Following the work of Mazzucato and other prominent scholars, the thesis argues against this neoliberal view, suggesting that the state has an active role in innovation.

The structure of the thesis is the following: the first chapter presents the research question of the thesis and its conceptual and analytical model. This part of the research aims to present the questions that will drive the thesis and the principal elements and relations that the research inquires. Chapter two discusses the concept of innovation. First, the general narratives and views of innovation in today's economy are described. The second part zooms into the innovation process by presenting two approaches, one based on anticipation and one on its practice. Chapter three is a review of the literature concerning the US space sector. This chapter aims to contextualize the chapter by describing its generalities. Chapter four presents the operationalization that the thesis follows in its analysis. Chapter five presents a summary of the main points of the two analyses. The reader can find the whole analysis process in Appendix A, and Appendix B. Chapter six discusses the findings and presents the results. The thesis ends with policy recommendations, reflections, and an overview summary of the work made.

Chapter 1

Research question

This thesis questions innovation as a process. The US Space Sector is the context of analysis of the innovation process. The reason behind the choice is due to the particular condition that the US Space sector is in. In fact, from a preliminary overview of the sector, it emerged that because of the particular condition that the sector operates in (i.e., space), there is a high level of technological development and knowledge production. On the other hand, the sector is relatively small without a significant presence of financial institutions and investment firms as banks. These two elements, the high level of technological development and the low presence of financial institutions lead to the particular condition of the sector, making it an interesting case study in which to study the innovation process.

From what is said upward, the following research question follows:

How does the innovation process work inside the US Space Sector?

The research question comprises two elements: the innovation process and the US Space Sector. The innovation process means that the focus is not only on the technological product, understood as the material components and return of investment. But, the inquiry of the research is on all the less

visible and tangible processes and parts that bring innovation into existence through technological production.
The second element, US Space Sector, is understood under the business ecosystem concept (Peltoniemi & Vuori, 2004). An ecosystem means that a set of actors interact with each other and are interdependent. The interdependent factor creates a co-shaping process in which the actors of the ecosystem, by influencing each other, determine the bigger context, which is the development of the ecosystem (Mäkinen & Dedehayir, 2012).
Because of these internal dynamics and interaction levels that bring innovation, the thesis makes sub-questions to analyze better and track the process involved.

Sub-questions:

1. How does the motivation inside the US Space ecosystem influence the innovation process?
2. How does the US Space ecosystem's strategy influence the innovation process?
3. How does competition inside the US Space ecosystem influence the innovation process?
4. How does the organization of the US Space ecosystem influence the innovation process?
5. How does the funding system in the US Space ecosystem influence the innovation process?

The five sub-questions are linked to the analytical and conceptual sections of the thesis. The explanation elements that the sub-questions are composed of are explained in detail there.
This paragraph explains the "why" for choosing these questions. The five elements are not isolated from each other; they interact. Motivation and competition refer to less tangible internal dynamics shaping actors' actions. Strategy and organization are more tangible and descriptive. They refer to the structure and architecture of the ecosystem through which the innovation process passes. By tracking the direction of the funding, it is possible to understand the sector's investment and what type of story that capital tells, making a more coherent picture of the innovation process.

Key concepts and analytical relation

This section of the research explains the main relation present inside the research from an analytical perspective. Each relation is linked to a sub-question, and it is present inside the conceptual model of the thesis. The context of application is the US Space sector understood under the concept of the business ecosystem. The section starts by introducing the concept of the business ecosystem. Then, it introduces the five elements of the sub-questions. At first, the framework connects one of the elements and the space sector. The scope of the connection is to define each element for the use of the thesis. There are cases in which the elements have connections with further components that are not directly part of the research analysis, yet they are relevant to the framework. For instance, from motivation follows status and reputation, or from organization follows institutions and center of knowledge.

Business Ecosystem

The first step is to define the key concept in this text: business ecosystem. A business ecosystem is quite a recent concept with several different definitions. In this research, it is used the one elaborated by Peltoniemi & Vuori (2004) defining a business ecosystem as a dynamic structure that consists of an interconnected population of organizations. This organization can be of several types (i.e., small firms, large corporations, universities, and public sector organizations). Following Peltoniemi & Vuori (2004), Radziwon & Bogers (2018), and Mäkinen & Dedehayir, (2012), the business ecosystem should be self-sustaining and developed through self-organization, emergence, and co-evolution helps to acquire adaptability. Another critical aspect of a business ecosystem is competition and collaboration presented simultaneously, leading to relevant analytical relations.

1. *Space ecosystem-motivation*

The following is an active relation. Broadly, motivation is why somebody does something or behaves in a particular way. The definition could seem simplistic, but it is more articulated than what may seem at first view. Kanfer (1990) states that motivation is difficult to measure because not directly observable. For this reason, he proposes that for a definition of motivation, three elements must be present to be adequate, and these are

1. variables that affect the stream of behavior,
2. a nomological network of relations between the variables and the implications of this variable,
3. the consequences of motivation, and how this can change future behavior.

Motivation in an action-making process stands one step first compared to strategy. Motivation leads to a decision on the strategy to adopt for reaching a specific goal. Therefore, the analytical correlation between the business ecosystem and motivation is part of a bigger picture in which all the ecosystem actors participate. The following parts of the research described in more depth correlation; these parts also reveal that all three single cases have their independent motivation.

Motivation can be deconstructed and linked to two components: status and reputation.

1.1 *Status and reputation*

The first step in this section is to define the two terms treated: status and reputation. Because of the interdependence of these two concepts, they were often used interchangeably or were using one as a component of the other (Pollock, Lee, Jin, Lashley, 2015). For this reason, the first step is the need for clarification. Following Rinnova and colleagues (2005), reputation is best understood as broad public recognition of the quality of firms' and individuals' activities and outputs. On the other side, status, for organizations and individuals, is broadly understood as the position in a social hierarchy that results from the accumulated acts of deference (Podolny, 2012).

When we apply status and reputation to the private and public sectors, we can notice that some differences emerge. Whereas & Byrkjeflot (2012) highlights five main issues of the public sector concerning reputation: political problems, consistency problems, uniqueness problems, charisma problems, and excellence problems. Regarding the space sector in this research for an analytical relation, the interest is in the last three points. These points are highly related to power and how this power influences the wait of acting, making a decision, public opinion, and context, but more in general, this contributes to creating a bigger narrative that distinguishes the US culture. In this context, culture has an anthropological use, defined as the complex of a particular society's knowledge, belief, values, and attitudes (Tharp, 2009). This definition of culture relates to the neoliberal view of the US economic system, in which the private and public sectors are embedded, thus influencing the US space industry and related narratives.

In their work on the co-evolution of status and reputation, Pollock, Lee, Jin, and Lashley (2015) suggest that the two elements can influence the flow of investment towards one side or the other, meaning that inequalities can rise in the US space industry. Analytically, the relationship between status and reputation in the private and public sectors gives an outcome that Collier (2018), Mazzucato (2020, 2013, 2015), and Fisher (2008) state in their work: the private sector is more dynamic also through the use of competition in creating reputation and status, and this attracts more talents compare to the public sector. As a result, there is more focus on commercialization and profit creation than social issues, sustainability, or more inclusive development.

2. *Space ecosystem-strategy*

Strategy is about shaping the future and how people (or organizations) attain desirable ends with available means (Mckeown, 2019). The analytical relations between the business ecosystem and the strategy are decisions and actions taken to achieve a predetermined goal (Zahra & Nambisan, 2012). Strategy is seen as a planning element, in a more general sense, is what guides the industry. Thus, the predetermined goal of the strategy shapes the organizational structure of the sector, and it influences the innovation process.

2.1.*Space ecosystem-innovation*

According to Peltoniemi (2004), the business ecosystem takes place in what she calls "an absorptive innovation strategy." The idea of this type of strategy is to spillover's effect with the firm's existing knowledge stock. This type of process, Peltoniemi says, enhances co-evolutionary processes. These processes open the possibility to horizontal innovation directions. The data analysis section attempts to prove this type of innovation relations empirically.

3. *Space ecosystem-competition*

This analytical relation follows the findings given by Ford & Håkansson (2013). The authors concluded that two types of competition could be found inside the business network. On the macro level, competition takes the form of a generalized advantage-seeking at the expense of the other components of the network. This form usually occurs when there are no existing relations between the components. On the other side, looking at the micro level, competition is an important variable. The reason for this is that a coherent pattern of relationship can be established for further business development (Distanont & Khongmalai, 2018). On the micro level, competition leads the single actor of the network (i.e., ecosystem) to seek benefits within and between relationships (Wu, 2012). From this understanding follows the analytical relation. Generally, competition in the US Space ecosystem is understood as the search for an advantage with market ends. Nevertheless, zooming into the ecosystem and looking at the single characteristics of the network, competition takes the shape of pattern relations between the actors. The characteristics of the companies based on their dimension and economic activity give rise to patterns between the actors. Competition is linked to the strategy of the ecosystem and further to the organization. Each pattern relation that companies create competes with each other in searching for economic advantage to get grants and finance contracts by thus organizations that create space programs.

3.1. *Innovation-competition*

Further, the level of competition affects innovation. Usually, the relationship innovation-competition is framed as a Schumpeterian effect (Aghion, Akcigit, Howitt, 2015), meaning that economic growth increases market competition between actors. This is understood as positive because, at some point, innovators would rise to break the market. Thus, the two factors have a positive effect (innovation + competition = creative disruption).

The statement of Teece (1996) confirms the above. The author, in his work, argues that the nature of competition is the most important driver of innovation, but not the only one. Also, other factors are essential: knowledge, capital, national factors, and especially spillovers that are highly present in the space sector.

Following the literature, the understanding of the relationship between innovation and competition is a non-linear relationship between market structure and R&D (Scherer, 1967). Based on this conceptualization, Kamien & Schwartz (1976) led to a theoretical interpretation based on empirical findings that resulted from a U-shaped relation. This relation means that in the model, innovation increases to a particular point with the intensity of competition and then decreases with the additional competition. The above shows that the relationship between innovation and competition is related to the organizational structure and the space sector's strategy. Moreover, as Wu (2012) demonstrated, competition levels influence the time frame of short- or long-term goals. Thus, affecting the economic behavior of the actors in the ecosystem (Wu, 2012).

4. *Space ecosystem-organization*

There are several ways to define organizations. The one that concerns the research describes it as the architecture of a determined system planned for a particular purpose (Cambridge Dictionary, 2022). Highlighting the architecture means that the connecting point stays in planning the ecosystem's structure at the analytical relations between business ecosystems and organizations.

What was sad brings a consequence that the organization of a system can have different structures depending on the single case; here, a question emerges: what type of organization has a business ecosystem? Even to understand the structure of the single ecosystem, we have to see the single structure, which is done further in the text when treating each case; in this section, it is possible to define general organization features inside a business ecosystem. Graham Astley & Van de Ven (1983) use a collective action view to define an organization when several actors are involved from a macro perspective. The organization structure, conceptualized by the two authors, is an interlocking system of exchange relationships negotiated between the different members of the system. The resulting network consists of a social action system of symbolical interdependence that takes on specialized roles with a shared framework of normative expectations over time. This type of network can be conceptualized under the term “epistemic communities” (Haas, 2021), meaning a common sharing of knowledge, practices, and language inside a community. Epistemic community is a relevant concept for the thesis, because the organizational structure of the ecosystem change according to the relations of these communities and their locations.

4.1. *Space ecosystem-institutions*

This analytical construction followed the work of Radziwon & Bogers (2018), viewing institutions as an orchestra of the ecosystem. According to the two scholars' work, there is always an orchestrator in a business ecosystem. The orchestrator's role is to support the development and enhancement of the performance of the ecosystem through innovation. Looking at the research case, the national space agency (i.e., NASA) identifies the orchestrator's role. Thus, there is an analytical connection between institution and organization, giving an outcome a better understanding of the structure and role of the business ecosystem inside the research.

4.2. *Space ecosystem-center of knowledge*

The importance of knowledge centers is a central activity for R&D. The analytical relation understands them as part of the US Space ecosystem, thus giving it a network understanding. Research in the field has shown the importance of network structure for the effectiveness of knowledge transmission and technological change (Broekel, Balland, Burger, van Oort, 2014). Knowledge centers play an essential role in the economic development of a sector, thus making it crucial for high-technical sectors such as space. Knowledge centers in this research are those organizations (such as universities, think-tank, and government research centers) that produce abstract, technical, and practical knowledge. As part of the ecosystem, knowledge networks transfer the knowledge produced through direct and indirect connections.

From a geographical perspective, it is important to identify these knowledge centers spatially. Broekel, Balland, Burger, and van Oort (2014), in their research, mention that an important finding in the field is that a substantial part of information and knowledge transfer takes place over long distances. Thus, firms and organizations have relations outside their cluster of geographical location. It follows that the location of firms and the setting are not isolated entities but embedded more broadly in a system of cities. From the above, it follows the description of the ecosystem context; thus, analytically, it follows that knowledge centers and their production affects the ecosystem.

5. *Space ecosystem-finance*

Generally speaking, finance is the ecosystem "engine." Nothing would begin without finance (i.e., money) that makes the ecosystem move, develop, and sustain all the activities starting. Finance in this section is not understood as the financial sector but as the economic actor that starts the investment in the sector independently from where the fundings come from (e.g., private capital, public capital, venture capital, charity, finance, and the stock market). Following this understanding, finance was located as a trans-level component in the conceptual model since the capital funding could have origin inside the ecosystem, outside the ecosystem but inside the US economy, or more generally from the world economy.

Conceptual model

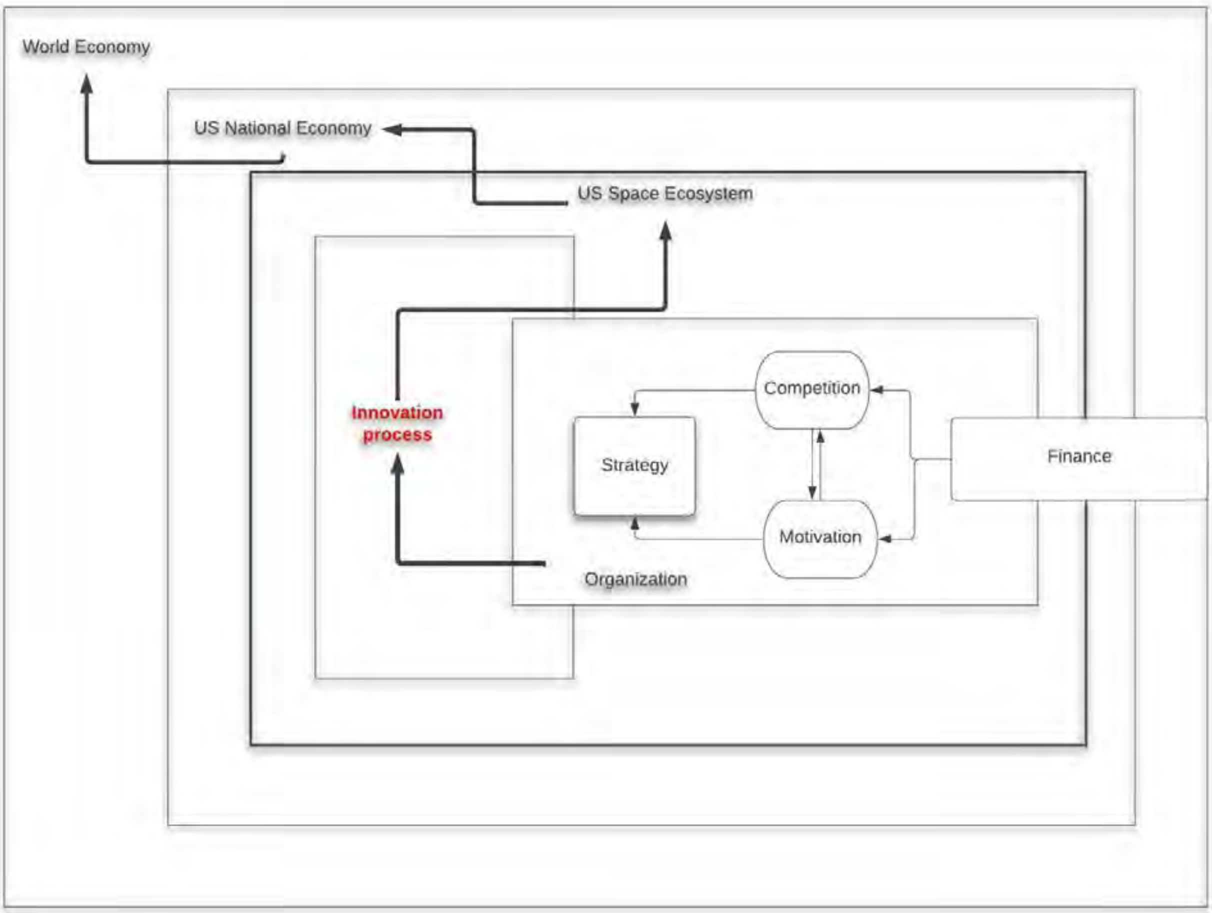

Figure 1. Thesis conceptual model (made by the author)

Description of conceptual model:

Different elements form the conceptual model. The US Space Ecosystem is the context. The Space Ecosystem fits inside a bigger context, that is, the US national Economy, which fits in the broader context of the World economy. The innovation process is the object of the study, making it the main character of the conceptual model. The arrow leaving the "innovation process" means that the result of the process goes inside a broader context until reaching the more general level of the world economy. Conversely, the arrow entering the "innovation process" means that the process results from its factors.

From the model, it is possible to notice that "organization" is the general factor. "Organization" refers to the architecture in which the other factors are located inside the ecosystem. The architecture of the internal organization regulates the interaction between the ecosystem's actors, thus, the innovation process. The factor "strategy" refers to the structural behavior of the actors inside the ecosystem. The element "strategy" is given from the interaction between the elements of competition and motivation. "Motivation" and "competition" are two factors that co-shape each other. The former refers to the internal dynamic behavior of the single actor of the ecosystem. The latter refers to a dynamic between the actors and shapes their actions. Both elements are linked to the ecosystem's active force, finance. Funding is necessary for the innovation process to start. Finance is an inter-contextual element because the flow of investment could arrive from any economic actor situated in all three layers of the context.

Chapter 2

Narrative and perspective of innovation in today's economy

Strange as it may seem at first glance, our economic and productive system has a problem developing and adapting to innovation. Paul Krugman (2021) called the latest technological gimmicks more of a game than innovation. In a nutshell, our system produces as it has never produced, but without innovating. This is because innovation is not a single action but requires the implementation of an entire context; otherwise, without it, the innovative product or technology developed would turn into failure. Mazzucato (2013) defines the construction of this context with the term "innovation system." Innovation is a factor within the production and economic system, but the capitalist system, in general, is made up of many other factors. A growing economic system may not have any innovative or R&D elements, as Mazzucato (2020) points out concerning the case of the British economic system, which is practically devoid of them. The point of divergence between innovation and growth rate lies in the highly uncertain nature of the innovation process. In general, innovation is seen negatively by both the market and the capitalist system itself due to the uncertainty that innovation brings with it (Mazzucato & Semieniuk, 2017). At first glance, this might seem a paradox if one thinks of the work of Marx, who attributes a central importance to the technological factor in the production of capital, or Schumpeter, who, in his writings, places market competition between firms and the innovative drive that arises from it as a central point in the capitalist system. However, let us proceed slowly and understand why innovation is frowned upon within the economic system.

The contradictions are to be found within the capitalistic system itself. Harvey (2018), in his book The Enigma of Capital, highlights how (at the time of writing, 2009) the value of world production would amount to 56200 billion dollars. The system conceives capital as a process in which money is sent in search of more money. Consequently, the system is effective if it has a growth rate. Again Harvey attests to the thinking of economists and the financial press, the idea that a 'healthy' capitalist economy, in which most participants make a profit, is an economy that expands at an overall annual rate of 3%, at lower rates the economy is said to be stagnant. Precisely for this reason, the system requires investments with safe returns rather than uncertainty provided by innovative exploration. The finance world also testifies this, in which the stock market often penalizes firms after announcing the start of an R&D project; innovation is a complex process that frequently fails (Mazzucato, 2013).

Schumpeter, in his work on innovation, coined the concept of "creative destruction" (Schumpeter, 2008). The concept describes the process of industrial mutation that incessantly revolutionizes the economic structure from the inside, leading to a new one with new actors in the market (Sidak, J. Gregory; Teece, David J., 2009). In his economic theory, Schumpeter attributes the role of main innovation drivers to large private companies. Further, he attributes it to the individual with a proactive economic behavior towards exploration. The exploration is optional for the capitalistic individual because capitalists, even by having capital, could have a passive attitude toward economic exploration. Therefore, the individual that Schumpeter refers to is the entrepreneur. In fact, like emerging from the work of Hagedoorn (1996), it is possible to find that, for Schumpeter, the entrepreneur appears to be the authentic and only economically relevant change agent of a pre-justified capitalist society. The Schumpeterian entrepreneur is, in the first place, characterized by his/her proactive behavior and not necessarily a strictly rational economically maximizing subject.

The problem of the innovation illusion of the economic system can be brought back, following the literature, to the banking system, to risk management, and especially to the finance system. Mazzucato (2013) (2017) says that Schumpeter's focus on innovation and inter-firm competition made him place finance at the center of his analysis. He called the banker the "ephor" of the exchange economy. He did not, however, Mazzucato says, look at the problem of what kind of finance is the best to serve the purpose of innovation. Paradoxically, the field of economics (orthodox as well as non-orthodox approaches) has not yet produced a thorough understanding of the link between invention, innovation, diffusion, and the financial analysis of risk uncertainty, and the type of financial structures that are key for the innovative enterprise to succeed (Mazzucato, 2013). Collier (2018) places his analysis by reflecting on the role that large enterprise plays in society through an applied role of technical exploration. The economic habitat is the market. The struggle for survival translates into competition. The beneficial dynamic of capitalism lies in the fact that, theoretically, competition and competitiveness should push companies to adapt and improve each time to have advantages. This behavior, at least in theory, leads to social benefits. However, there are interests and strategies applied to these interests. Following the context and looking more specifically at the case, Pisano (2006) argues that the stock market has never been the adequate instrument to manage the governance problems of those firms in which R&D plays a driving role. Collier (2018) places even more of a finger on the financial sector, describing it as a 'zero-sum' tournament. The author explains how we find innovation at the opposite end of the spectrum from financial asset management. Economists estimate that typically an innovator only takes about 4 percent of the total revenue generated by his innovation: the remaining 96 percent goes to everyone else. Thus, the market's incentives for super-performers to deploy their rare skills for innovation are too weak, while the incentives to use them for financial activities are too strong. To conclude his analysis, Collier reflects on the dispersion of talent that zero-sum financial tournaments bring; the ability to win these "tournaments" can bring enormous benefits at the expense of the losers. Furthermore, as Collier (2018) writes: "Too many of our most talented people devote their skills to these kinds of zero-sum games, while activities such as innovation, which bring great benefits to society as a whole, are in short supply of talent."

Fredrik & Bjorn (2017), in their book "The innovation illusion," offer an excellent analysis of the contradictions of today's capitalist system. The authors use the metaphor of the "four horsemen of capitalist decline" to refer to those elements that characterize today's production, i.e., a system that produces but does not innovate. The four elements are grey capital, corporate managerialism, globalization, and the regulatory system.

With the first concept of grey capital, they refer to 'grey ownership': i.e., today's cooperatives have an anonymous center with no real owners, only controlling owners. Shareholders control the various properties, such as portfolios and investment institutions, and are unfit to make decisions. In short, this leads to a quest for safe and continuous growth, in stark contrast to what is a capitalist exploration. Following the above, today's capitalist system is without capitalist owners. It is the world of finance that controls the market.

Mazzucato (2013) argues that the problem of the ideology surrounding this role and the stock market in innovation, and the analysis of the sources of innovation, has so far prevented a "healthy balance" between speculation and time-sensitive investment because there is an obsession with capital gains and quick placement on the stock market.

The second point that the authors identify is corporate managerialism. These undefined owners require corporate managers to guide their companies and pursue their investment objectives. Business today is incredibly managerial. As John k. Galbraith argued in his book 'The new industrial state,' "the real enemy of the market is not ideology but the engineer." By this strong statement, the liberal guru meant that managerial business aims to minimize uncertainty. Thus, it is a limitation of innovation exploration.

The third "horseman" described is globalization. It is a significant phenomenon in today's world economy, redefining boundaries, deterritorializing the market, and breaking up the supply and value chain. It has brought the market to a global level, creating a global economy. A crucial phenomenon of today's society, actively shaping our world.

The last aspect that Fredrik & Bjorn (2017) discuss, directly related to corporate managerialism, is the regulatory system. Today's capitalism is characterized by complex regulatory rules trying to combat uncertainty. Despite more than three decades of liberalism, reducing economic regulations even to the detriment of worker protection, other types of regulations have interfered with the process of innovation, directing the flow of capital forces toward the search for stability and predictability. Many researchers argue that many of the recent trends in intellectual property protection, i.e., the increase in patenting in upstream areas of the production chain, such as "research tools," have reduced the rate of innovation because they prevent scientific research from progressing in an open and exploratory way (Mazzoleni & Nelson, 1998).

Grey capitalism, outlined above through its four main characteristics, channels capitalist forces onto themselves, suffocating them. It describes what capitalism is today but needs to look at what are the primary characteristics of capitalism.

To conclude this paragraph, the role of imagination must be mentioned, which is also a fundamental part of the market dynamics within the innovation process. Harvey & Sala (2018), in their book "Marx and the folly of capital," reworking the ideas of the German economist, considers ideas, knowledge, and imagination as gifts of human nature so that they become fundamental inputs of use-value in technology and production. The idea of human nature gives a significant role in the imagination and abstract processes and is of primary importance in the labor process. To summarize, the capitalist system's intellectual properties bestow a specific aesthetic power intrinsic to the innovation process, especially from the spatial perspective. There is a link between these intellectual properties and the economic perspective described above. These are the inherent property of the power of narratives that the capitalist system brings with it concerning the growth rate, which both Mazzucato (2013) and Collier (2018) mention. In this sense, further analysis can be offered, with a different perspective concerning the capitalist system, the work of Mark Fisher, who treats cultural theories as a critique of the social system. His is an exciting work, which unfortunately does not find space for further study but deserves to be mentioned.

This chapter aimed to identify the innovation problem facing our economy and production system. To summarize and take stock of the current state of affairs, the thesis uses material from both sides of political thought, both those with more liberal and those more state-oriented. The text investigates how these different perspectives and narratives interact in the US space sector. The interesting thing to note is that both make similar criticisms, agreeing on various points and recognizing the problem. Diversity emerges in the solutions provided to break this deadlock in the innovation system.

Further, the thesis tries to see the processes that these narratives create. The space sector is identified as an innovative system (Mazzucato, 2013) in which multiple actors interact to develop the sector. Due to its complexity and the system and network creation, it needs to expand and develop; space is seen as a key development sector at a regional and national level. From an innovative and system point of view, space is a compelling case of analysis due to its tradition as a state-driven sector, the low presence of financial institutions but with high technological requirements, and the increased interest by private companies.

Innovation: between anticipation and practice

Innovation has become one of the most critical issues in the modern knowledge society (Peschl & Fundneider, 2008). It is a term embodied with an attractive force. This term has often been used for seductive purposes in the marketplace to indicate that a specific product or company has radically improved over its competitors. The term designates a change from the previous condition in a positive way, a substantial improvement that provides a paradigm shift. With this, it is meant the creation of new practices, concepts, knowledge, and processes that fundamentally differ from the previous one, making them no longer applicable in the new paradigm. Those who do not adopt this change are not in step with the times; they cannot compete with their competitors shortly. The term innovation implicitly indicates that those who do not adopt it are doomed to extinction on the market. However, those who innovate too much, or anticipate innovation too far concerning the context, are also doomed to extinction. Balance is needed. A balance that is not part of the definition of innovation itself. Schumpeter gave one of the first definitions of innovation, describing it as "innovation implies bringing new into use." There are still ongoing debates about which definition is better (Summerer, 2009), but in this sense, the most accurate to our context is the following, taken from the European Commission's Green Paper on Innovation of 1995:

"Innovation is the renewal and enlargement of the range of products and services and the associated markets; the establishment of new methods of production, supply, and distribution; the introduction of changes in management, work, organization, and the working conditions and skills of the workforce."

The market has difficulty adapting to innovation (Mazzucato, 2013) because it is a context of a very wide maneuver in which different actors and shareholders come together. On the other hand, the market is always looking for innovations to open new economic outcomes (Mazzucato, 2016). In this section, the text digs inside the literature on innovation. We will start by treating it in a general sense through an approach in philosophical and cultural terms, then go into a more political and financial context. Peschl & Fundneider (2008), in their paper, introduce the concept of emergent innovation. This approach looks at innovation as a socio-epistemological process of "learning from the future." Thus, innovation is a result that "emerges" from times, which looks to the future through the conditions of the present. Broadly, the space sector and its development is an emerging innovation, as it is the logical result of a process that takes place in the future, not only from the point of view of technological evolution but of the entire human species. This development is because, as Peschl & Funddneider (2008) point out, innovation is, in a certain way, knowledge at work, and the creation of new knowledge is the key for almost every domain in society, business, or organization. Innovation and knowledge are intrinsically coupled. Innovation is a matter of the future, and "how" to behave regarding it is the central challenging process.

The future is almost impossible to predict accurately because of the incredible complexity of the underlying social, economic, technological, and knowledge dynamics. The only way one can achieve this control, according to the two authors, is to create new knowledge and apply it in various contexts. The authors create s framework in which it is possible in six points: acquiring knowledge, (ii) abstracting and constructing knowledge, (iii) creating new knowledge, and (iv) realizing this new knowledge in concrete prototypes; (v) after fast cycle learning processes on these prototypes (iv) this newly generated knowledge gets embodied in the organization. Peschl & Funddneider (2008) investigate this phenomenon at a fundamental level. They seek to understand the change from an existential perspective, reflecting and learning from it. In a way, the goal is to bring the existential level of the person and the organization into a status of inner unity and alignment with its future potential and requirements (Peschl & Funddneider, 2008). The authors refer to Aristotle's philosophical thought, and although it may seem esoteric, therein lies a fundamental knot. The question concerns the domain of the core/ substance of the innovation object and wisdom. It refers to this mode of change/teaching as "presencing" (Peschl & Funddneider, 2008). The above is relevant to our context when translated to the approach to innovation. In this approach that the two authors present, innovation (view as change) does not learn from the past but focuses on "learning from the future as it emerges." As described by the two academics, the aim is to be close to the innovation object and, simultaneously, completely open to "what wants to emerge." The tricky part in this consists of three parts: (i) to profoundly understand the situation plus its context, (ii) to match these insights with the potentials which want to emerge, and (iii) to bring them into a consistent and integrated picture (Peschl & Funddneider, 2008).

Innovation can also be seen as social practice (Clercq & Voronov, 2009). Starting from Bourdieu's theory of practice, meaning an individual's everyday practices are embodied and tacit, the two authors attribute a cultural and symbolic value to capital. The capital created by new knowledge and practices in the first place leads to the innovation process. Therefore, the conclusion is that innovation is not only about anticipating the future in an Aristotelian sense but also has an everyday dimension: social practice. This process leads to new forms of knowledge and practices that have tangible outcomes in the application context. The openness of the sector, its development, its innovative mechanisms, and how it adapts and changes to them are part of the emergence of the times. It is an outcome of the future that finds its development in the 'past' (and present). All the problems our society faces are symptoms of one big problem: reaching the limit of planetary civilization (Metzer, 2016). Following, the future calls for the emergence of the present, in its need for innovation and new knowledge to adapt to the context, and space, in this sense, is one of the possible paths.

When discussing innovation theory from an economic and market perspective, the concept of disruptive innovation is often mentioned. Christensen coined this term for the first time in his book "The innovation dilemma." With this term, the Harvard guru defines "an innovation that customers cannot use in mainstream markets, and it defines a new performance trajectory by defining new dimensions of performance compared to existing innovations. Disruptive innovations create new markets by bringing new features to non-consumers or offering more convenience or lower prices to customers at the low end of an existing market (Christensen et al., 2004). Today's space sector offers both characteristics in its relationship with emergent and disruptive innovation. Whether it is successful or not is determined by various factors and how they fit into the context. In general, one can attribute their success and adaptation to the market to the time of their emergence. In classical literature, the direction of innovative adaptation is conceived as a process of bottom-up adaptation (Kollars, 2015). In Kollars's (2015) study on innovation assimilation under extreme conditions (her work is about how soldiers adapt to innovation on the battlefield), she concludes that innovation is a phenomenon of pure-directional transfer and adaptation. In this sense, the trajectories of adaptation are similar in the space sector. Summerer (2009) emphasizes the technology transfer from space to the non-space sector. As an example of this, the technology transfer program of ESA has published the successful transfer of over 200 space technologies to non-space sectors for applications as diverse as cooling suits for Formula 1 racing teams, ground penetrating, radar to detect cracks in mine tunnels, and several health-care innovations (Summer, 2009). Schmidt & Druehl (2008) point out that for an innovation to be disruptive, it must follow bottom-up ontological and adaptive trajectories. The research disagrees with them; what Kollars (2015) and Summerer (2009) say above seems the opposite. The thesis argues that the space sector offers disruptive innovation creation because many innovative technologies in the new space economy touch on the four points that Christensen, Johnston, and Barrage (2000) indicate as key characteristics for disruptive innovation; these points are:

1. Targets customers in new ways
2. Generally lowers gross margin.
3. Generally needs to improve performance along the trajectory traditionally valued by mainstream customers.
4. Introduces a new performance trajectory and improves performance along with parameters different from those traditionally valued by mainstream customers

In support of this, Summerer (2009) gives the example of CubeSat activity (nanosatellites), analyzing it precisely through the disruptive innovation conceived by Christensen. This example respects a general rule of Christensen (2004), who argues that disruptive innovation new-market innovations are low priced (usually).

With this, we have seen that innovation in the space sector is a phenomenon that emerges and is disruptive. However, looking at it in concrete terms, how does the technological process work?

Moreover, how does it differ from other sectors? Mazzucato offers a series of research in which she discusses innovation and how it fits into the system between finance, policymakers, and public investment. In the first paper, "Financing innovation: creative vs. destructive creation," from 2013, the author states that to understand the relationship between finance, innovation, and growth, one must start by understanding the profoundly "uncertain" nature of innovation. Technological change produces uncertainty for all economic actors involved, those who invest in it and those who experience its effects. It is paradoxical, Mazzucato continues, that the field of economics has not yet produced an in-depth understanding of the links between invention, innovation, diffusion, and the financial analysis of risk and uncertainty, and the type of financial structures that are fundamental to the success of an innovative enterprise. In her analysis, she points out that because traditional profit-maximizing banks fear the uncertainty underlying innovation, innovation has often had to be financed by alternative sources (such as venture capital, business angels, or public funding agencies). From these two factors, we have, as a result, the fact that nowadays, banks seem not to know how to differentiate "good" risk from "bad" risk that arises from weak economic performance or speculative activities and increased debt (Mazzucato, 2013). Mazzucato underlines the role that innovation has on small firms and large firms. Small firms focus on R&D "exploration" activities, while large firms focus more on "exploitation" activities. Indeed, precisely because innovation is a complex process that often fails, the stock market often penalizes firms after they announce the start of a challenging R&D project. From a policy perspective, Mazzucato says it is crucial to consider how the "ecosystem" of financial institutions can "broaden" the innovation landscape. One way lies in the pure-directional nature inherent in innovation discussed earlier. Indeed, it is possible to succeed by channeling pure innovation through a "mission-oriented" investment via public investment. A contrast emerges when discussing private and public investment, which has to do with objectives and time horizons.

The diversity of views creates tension between the role of finance in nurturing and penalizing innovation. The tension has to do with the ability to facilitate the process of value creation in the economy or extract it. Indeed, private finance pursues short-term profits and focuses on value-extraction activities, which implies that only public finance can often provide the long-term patient capital that fuels learning and innovation (Mazzucato, 2013). The key issue, Mazzucato says, is how to de-finance companies in the real economy and find ways to reward value-creation activities over value-extraction activities. Starting from this problem and its origin, Mazzucato developed the concept of the 'entrepreneurial state: that is, the willingness to invest, and sometimes imagine from the outset, new high-risk areas before the private sector does. Firms have tended to enter new areas only after the high risk and uncertainty have been absorbed by the public sector, especially in capital-intensive areas (Mazzucato, 2016). In this sense, space is an example, as the sector's history demonstrates.

The mission of the entrepreneurial state (that in the thesis is represented by NASA and other government institutions) should be broad enough to catalyze many different sectors so that the public and private sectors work together to create new technologies and sectors (Mazzucato, 2016). The collaboration starts because the innovation system, from a practical perspective, focuses mainly on building links between actors for knowledge circulations and its diffusion throughout the economy (Mazzucato, 2016). Smart specializations with technology transfer are created, as Summerer (2009) describes in the case of ESA. Mazzucato (2017) points out the history of innovations and shows that it requires a market-making and market-shaping approach. This approach is due to the great uncertainty that characterizes innovation, given by an asymmetry of information (Mazzucato, 2017) derived from the future. Again, the epistemological importance of emergence. Concerning the entrepreneurial state, Mazzucato (2017) associates an innovation policy that she calls "mission-oriented." It is a strategy of policy-making defined as systemic public policies that draw on frontier knowledge to achieve specific goals or "big science deployed to meet big problems." The archetypal historical mission is NASA's putting a man on the moon (Mazzucato, 2017). The funding of mission-oriented innovation by the public organization, for Mazzucato, should be entrepreneurial. This is because, echoing Schumpeter's thinking, the entrepreneur is the only economically relevant agent of change in a society of capitalists (the entrepreneur is understood as any entity willing to invest competitively and innovatively). This conceptualization is because his behavior is proactive and not necessarily a strictly rational economically maximizing subject (Hagedoorn, 1996), meaning someone must take the risk.

Chapter 3

The space sector: a review

The object of this chapter is to review the literature on the US space sector. To do this, the thesis uses not only academic publications but policy documents, reports by research and economic institutions, and grey literature by lay audience sources taken into consideration as well. The aim is to describe the context of the US space sector by making an overview of what the sector is. Space is a grand societal challenge due to the complexity and possible social impact that its development could have on society. This chapter's review will be the starting point of analysis in the discussion and results chapter.

The chapter is divided as follows: first, it outlines the difference between "old" and "new" space. Second, it highlights the economic value of the sector. Third, it presents the institutional description of today's sector. Fourth, it describes the relationship between the space industry and innovation activities. Fifth narrates the future possibilities and development of space. The fifth section is speculative, but it is helpful because it shows what type of imaginations narratives space allows. Six, the US space sector is presented under the business ecosystem concept. This ontological definition will apply to all the thesis. The last section focuses more deeply on the US space context.

"Old" and "new" space:

When we want to analyze and define the space sector, it is appropriate to divide it internally into two macro-areas: the "old space" and the "new space."

Robinson & Mazzucato (2018). There are no clear and uniform definitions of the two concepts of old space and new space; however, the authors provide common characteristics that give guidelines for understanding the differences. Weinzierl (2018), Orlova, Chimenti, Nogueira (2018), Whelan George (2018), and Crawford (2016) all agree on this internal separation in the sector. From a chronological point of view, the separation between the sectors is tracked back to the beginning of 2000; it was from these years that the private sector consolidated (Cornell, 2001), represented by prominent entrepreneurs in the technology sector, started to invest more and more in the sector. Most recent space companies are privately funded (e.g., Space X, Blue Origin) and not publicly traded (OECD, 2019).

Concerning "old space," Robinson & Mazzucato (2018) highlight the importance of governments and institutional bodies in financing technology development and applications of the sector. From an economic perspective, the market mainly comprises a business-to-government or business-to-business. Similarly, in his work, Weinzierl (2018) also focuses on the role of governments and institutions. He describes the sector through a centralized model in which the government took the investment risks from the private sector through cost-plus contracts, but on the other hand, the private sector had little freedom to take advantage of the commercialization of the space market. It is easy to see, although in different words, that both works highlight the central importance of the public sector. As far as the "new space" is concerned, Robinson & Mazzucato (2018) point out that the origin of investments has changed from public spending to other financial instruments, such as venture capital funds or investments financed by large high-tech companies (Google, Facebook, Apple, Virgin). The different funding origins also lead to different market commercialization, creating a market that focuses on business-to-consumer service. In a more general sense, Weinzierl (2018) defines the "New Space" approach proves firms share the enormous risk and potential returns of the space investment. If Robinsons & Mazzucato (2018), and Weinzierl (2018) focus on the economic aspects of New Space, Orlova, Nogueira, and Chimenti (2018) instead in their work quote Saverio Calderoni. Calderoni, a specialist in European New Space, explains how the shift between new space and old space is not only from a change in the commercial perspective and, therefore, also from the origin of capital inflows but is, above all, a cultural and philosophical shift within the sector, leading to greater private participation. Following this path, Crawford (2016) focuses on the secondary aspects that the new space economy can bring in terms of space exploration, thus enhancing scientific research and understanding of our universe. Crawford points out that the entrepreneurs of the space sector behind the commercialization activities are seeking to make a profit, and the bigger the space sector becomes, the bigger the profits generated. The profit increase would lead to further development, increasing the opportunities for scientific discovery. Putting together all these various characteristics that the authors bring out from their work, the new space is the commercialization of the space sector by private individuals whose risks and markets are shared within the public sector. This combination leads to a change of perspective, which has consequences in society, bringing the outcomes of the sector closer to everyday life. Embedding space activities in everyday life (such as satellite communication and navigation, data collection, and national security) leads to a shift from an abstract perception far from everyday life to a much more intrinsic and articulated condition. Due to its profit-driven commercial applications, the intrinsic property that the sector is developing increases its secondary effects (spillovers), both in the immediate present and future, such as the example hypothesized by Crawford on space exploration. In continuing the description of the space sector, this research focuses on new space; old space is only important in the more general context of the evolution of the sector's process.

The economic value of the space sector:

Looking at the space sector's figures and forecasts reveals a centrality in the near future. The global aspects of the space sector give this. When talking about space, generally, the tendency is to think of the man in space and the colonization of distant worlds along the lines of the "men-on-the-moon" mission. However, the field is much broader than it might appear at first glance. The benefits of space are not exclusive to space actors, as many studies report positive effects in non-space companies and at a broader societal level. This expansive landscape leads to positioning the new space within the global value chain (OECD, 2019). In their review of the literature on the sector, Orlova, Nogueira, and Chimenti (2016) find that twenty-one actors emerged from the analysis. They argue that the backbone of the sector is the launch vehicle and satellite manufacturers, with the telecommunication industry's being the most significant sector as a customer. According to the OECD report (2019), the space economy is recognized as a major driver of economic growth. The space economy currently is valued at $350 billion annually, with an increase of $500 billion by 2030. A 2018 report by investment firm Goldman Sachs also predicted the space economy to reach $1 trillion by 2040, while another study by Morgan Stanley predicted a space economy of $1.1 trillion by 2040. A third study by Bank of America Merrill Lynch has the most optimistic outlook, seeing the market grow to $2.7 trillion in the same time frame (Bryce, 2018)

The following analysis shows the short and medium term, thus predominantly for activities involving satellite and communication services. In addition, in other statements emphasizing the economic magnitude that the sector has in its potential, both entrepreneur P. Diamandis and astrophysicist N. G. Tyson claim that the first trillion dollars will be an asteroid-miner (as reported in Kaufman, 2015).

One last significant economic value the space sector has is the technological ownership of transfer. This means "The process through which a technology originated in one sector finds an application in another sector is called technology transfer." The term denotes any "movement of know-how, skills, technical knowledge, procedures, methods, competencies or technologies from one organizational context to another," as reported in the OECD (2019) report.

The interest in technology transfers from the space sector to other sectors of the economy has been growing in recent years, reflecting the increasing attention to space applications and their potential to generate socio-economic benefits beyond space missions for the economy and society (Jolly & Olivari, forthcoming). The transfer process is essential for two reasons: first, it contributes to broader socio-economic development, mainly due to its impact on innovation in different sectors (OECD, 2017). Second, technology transfers act as a strategic channel to stimulate and trigger innovation creation and propagation mechanisms, utilizing knowledge spillovers through industry-science collaborations and technological transactions between various actors (OECD, 2016).

The institutional framework of the space sector:

The previous section is essential to understand its potential economic volume space. For this intrinsically valuable fact, it is crucial to summarize the point of the institutional regulations concerning it to understand the freedom of movement in the sector and related gaps from a key development perspective for the innovative field.

Today, the most widely adopted agreement on space law is the "Outer Space Treaty" (OST), developed by the UN in 1967 and signed by 102 states. The OST actively promotes international partnership and peaceful uses of outer space, believing that outer space is a common resource, similar in many ways to the high seas. This agreement prohibits any claim to sovereignty or ownership of celestial bodies but specifies nothing about using resources by private entities. This lack of clarity led to an attempt by some nations to implement a more restrictive agreement, the 1979 Moon Treaty, but the space nation did not sign it. In summary, the "Moon Agreement" offered a model of ownership of all resources by all humanity; on the other hand, the "Outer Space Treaty" established the rule of no ownership in space and unrestricted access to all space (D. Paikowsky & R. Tzezana, 2017). In 1984, President Reagan signed the "Commercial Space Launch Act"-this act had no immediate action (A. Dula, 1985) but would prove fundamental in the American scenario for the creation of the new space, bringing its effects on the global landscape of the sector.

The resulting ambivalence over property rights in space had no real effect for decades. However, with the rise of commercial space, the choice of a regulatory approach to property rights has taken on a new urgency (M. Weinzierl, 2018). In 2015 under US President Barack Obama, the first national regulatory act for outer space activities was implemented. The Commercial Space Launch Competitiveness Act states that the United States does not claim sovereignty, exclusive rights, jurisdiction over, or ownership of any celestial body. However, it includes provisions to protect private companies' property rights that will use celestial bodies to create economic value (D. Paikowsky & R. Tzezana, 2017).

The importance of institutional regulation on the activities of the space industry worldwide is crucial for the near future, as has been pointed out, not only for the regulation of its exploitation by private individuals and state agencies but also for the right of ownership, both physical, intellectual, and technological. However, there is also a change in the economic model on Earth. Paikowsky & Tzezana (2017) point out that the current economic model on Earth is scarcity base (i.e., having limited resources and being forced to compete for them). Space economics and industry development is a "disruptive" technology (this concept is analyzed further in the research) that could profoundly impact many industries and the economy. From the research material used for this section, one problem is the fear that an elitist monopoly may emerge among both countries and private companies through the current regulation system concerning space activities. Two interesting solutions are proposed to overcome this, and it is worth mentioning them for future reflection. The first is the concept of "Partial Ownership," introduced by Beauvois & Thirion (2020). According to the authors, this system allows competition for valuable resources without a grating monopoly, as it keeps the competition for ownership open. The second proposal is creating a space bank, proposed by Paikowsky & Tzezana (2017). The authors base their research on a simulation game played by their students after adequate preparation. From this simulation, the idea of a space bank emerged for a fairer distribution of the proceeds of space exploitation. It was found that while spacefaring nations were mainly eager to exploit resources from space, most developing nations on the simulation were far less excited about the possibility and understandably feared that this technological breakthrough would disrupt their growth and development by making their natural resources virtually worthless overnight (Paikowksy & Tzezana, 2017). Both of these proposals are interesting and certainly deserve further study and reasoning in this regard. An institutional analysis of the space sector is not central to the following research, but a quick summary was appropriate so that the reader has a clearer idea of the sector's generalities and the completeness of the work itself. To conclude, space has several potentials, but potentially the greatest one is economical.

The United Nations, through their UNOOSA office and other groups, including ECSEC, and SGAC (Space Generation Advisory Council), are trying to make space more inclusive, intended for all societies' good. For this reason, more critical research into its regulations so that it can bring about more significant action is most welcome. Otherwise, there is a risk of increasing inequalities between those who can afford access to and use space and those destined to remain reclusive on Earth. The creation of a policy and legal framework is also important, as the OECD (2019) points out, for adequate regulation of technology transfer between the space sector and other productive sectors, thus facilitating the process.

Innovation in the space sector:

Innovation has been a key parameter since the early days in space (Summerer, 2009). There are wide studies on the dynamics of innovation; however, most of this research is in competitive market environments, where the supply or demand side of the market can be identified as a driving force for innovation, but what about space? The first thing to do in this part of the text, to better understand how innovation fits into the space sector, is to divide the sector into two given historical moments. There are no clear definitions of this, but Robinson & Mazzucato (2018) offer a comparison between "Old Space" and "New Space." In 'Old Space,' government and institutional bodies founded technology developments and applications. There is an emphasis on high-end, highreliability technologies. The space market is mainly composed of business-to-government or business-to-business services.

In 'New Space,' investments for projects are provided by venture capitalists and large companies (Google, Apple, Facebook, Virgin). There is an ethos about mass production, implementing business models with high production rates and low cost per unit. The market focuses on business-to-consumer services.

New Space is to be a key driver in the global space economy, and it is particularly prevalent in the US. This phenomenon puts pressure on the industry and the European space agency (Robinson & Mazzucato, 2018). In December 2016, ESA Director General Jan Worner proposed his vision of Space 4.0 in response to the new space scenario emerging in the United States. Similar to the notion of Industry 4.0, which is a collective term for transformation across the value chain of different sectors, involving new interactions between public and private sector organizations, both upstream and downstream (Culot et al., 2020). Space 4.0 focuses on interconnecting science, industry, policy, and society in new ways; this implies supply chain and service interconnection (Robinson & Mazzucato, 2018). At the same time, the space sector is trying to reposition itself along with new societal challenges, ranging from climate change to immigration, while also playing a role in the digital economy (McGrath et al., 2014). While there are changes in the space innovation system, public agencies are experiencing budget cuts and pressure to justify their activities against the production of socio-economic value (Robinson & Mazzucato, 2018). The pressure has meant that commercialization and market creation activities are prioritized more than ever, with agencies aiming their activities closer to downstream applications, products, and services and having to show the effect of indicators such as jobs, new business formation, and economic growth (Besha & MacDonald, 2016). Thus, the challenge for NASA and ESA is to develop market-creating innovation policies in response to

1. the growing emphasis on grand societal challenges,
2. the rise of a new wave of space companies, and
3. the global trend towards interconnecting and linking industries.

Several approaches can be used to develop these points. In their research, Robinson & Mazzucato (2018) conclude that market failure and innovation system failure are not the best solutions to achieve the goal of this type of market development and construction. This is because, for the market failure theory approach, there would be a need for immediate returns that affects private R&D investment. On the other hand, the fixing innovation system approach focuses on optimizing the performance of the innovation system, which is related to the nature and quality of the interactions of the actors in the innovation system (Robinson & Mazzucato, 2018). Space can be understood from the perspective of grand societal challenges (Cagnin et al., 2012), capturing social needs that are currently unmet and often require international and multi-sectoral solutions. The nature of grand challenges is complex due to various interdependencies that make problem-solving approaches difficult to articulate (Armanatidou et al., 2014), translating grand challenges into concrete actions (Robinson & Mazzucato, 2018). Mazzucato (2017) proposed that challenges can be translated into concrete actions through an intermediate layer of mission-oriented innovation policies to create, shape, and direct markets that would otherwise not occur through correcting market and systems failures. Mission-oriented policies aim to develop specific technologies aligned with state-defined goals (Robinson & Mazzucato, 2018). In their conclusion, Robinson & Mazzucato (2018) come to the following conclusions: Mission-oriented policies need to be enacted in a decentralized and distributed innovation system, linking broad, complex, and often contested challenges with concrete problems to be solved by innovation actors, particularly around market creation. Public space agencies play an essential role in both the US and European space sectors; in particular, their role is to

1. create links between the non-space innovation system and the space innovation system,
2. coordinate long-term infrastructure with 'public good' characteristics, and
3. catalyze and govern space innovation systems.

The future of space, say the two authors, would be determined by breaking the dichotomy between "old" government and "dynamic" entrepreneurs.

The future possibilities of space:

The first to lay the groundwork for a space economy was Princeton physicist Gerard K. O'Neil. Inspired by the pioneering work of Konstantin Tsiolkowsky, O'Neil realized in the early 1970s that space could be the answer to many of the Earth's problems. Throughout his career, he sought to disseminate his programs for the productive use of extraterrestrial space. His programs, based on physical knowledge and which analyzed the engineering components in detail, aimed to use space in three ways: energy production, mining of celestial bodies and the processing of these materials in space, and colonization (National Space Society, 2018). Although his analyses showed that the realization of such programs was possible with the scientific knowledge and technology of the time, O'Neil's proposals were rejected by politicians and decision-makers.

As Tsiolkowsky inspired O'Neil, today, O'Neil inspires the people in today's sector. The planetary physicist Philip Metzer draws his work exploring the potential possibilities of space. Metzer (2016) tries to demonstrate the importance of the space sector today, updating it technically to the present day. The importance of Metzer's work in the context of this research is for the creation of the argument that because of the unique conditions of space today (i.e.the ongoing development of a sector that did not exist and the high technological requirements). According to Metzer, these conditions lead to a bigger innovation capacity than other sectors. Space programs will be more cost-effective when they establish a supply chain in space, mining, and manufacturing, then replicate the assets of the supply chain, so it grows to a larger capacity (Metzger, 2016). An essential part of this is technological development, especially robotics. Today it is possible, says Metzger, to create an industrial supply chain in space, enabling great science while promising tremendous benefit on Earth. The ultimate goal is a Self-sufficient Space Replicant Industry (SRSI) based on bootstrap reproducibility. To achieve this, technology, and especially robots, play a central role, both from an infrastructural and operational point of view and in terms of cost reduction.

Today, there is a slowdown in the terrestrial industry to adapt to automation, so if we look at individual terrestrial factories, it is challenging to get an appreciable idea of the level of automation our production system has achieved. An example is "Fanuc," a Japanese company whose factories are fully automated. In this sense, we can agree with Bill Gates when he stated in 2007 in the Scientific American Journal that "robotics is developing in much the same way that the computer business did 20 years ago". Robots, it is worth pointing out, would solve the problem of human labor in zero gravity, one of the main problems of the past (see the work of Sandler & Schulze, 1985). Technology developed for space can also be reused on Earth and vice-versa. This is undoubtedly positive because different situations lead to different problems and solutions. Technologies developed in space might not be developed on Earth because the conditions for their realization would not be available there, but this does not prevent these technologies from finding applications in the terrestrial context, just as the opposite is true (spillover effects that are treated in a further part). Technological development is linked to a reduction in costs. However, as Metzger rightly points out, we have yet to reach the point where robots can repair themselves, despite the deep learning artificial intelligence neural networks in robots. Thus, the associated cost increase is still making the role of astronauts central.

Nevertheless, although the costs are still high, the benefits of the investment, according to Metzger's analysis, are worth the effort. The article, looking only at the economics, shows that the scientific benefits alone justify space development. Looking at Metzger's analysis in more detail, there are five main sectors within the space economy in the form of SRSI. These are minerals and manufacturing, data and computing, energy, existential benefits, and space monitoring. Following is a summary of the five:

a) Mineral and manufacturing:

The United Nations predicts that by 2050 the human population on Earth will expand to 10 billion and 11 billion by 2100; it is true that, as reported in the book Factfulness by Rosling (2018), after that, the population is estimated to balance out. However, this still represents a vast number of people. In short, our society today is approaching the limits of a planetary civilization. Every production activity impacts the planet and its ecosystems, from extraction to product manufacture. Moving the production system, or at least part of it, into space would help relieve the pressure on our planet, and space conditions could also help some types of production.

b) Data and computing:

The Royal Society, the Semiconductor Research Corporation, and Industry Association have stated, "Unfortunately, neither existing technologies nor current deployment models will be able to support the sky-rocketing demand for communication, especially in the wireless sector" (Metzger, 2016). This increase is because the use of computers and the internet has grown exponentially in recent decades, and because it is exponential, it is easy to reach a physical limit of growth. In the paper, Metzger suggests moving most computers into space and using satellites as a bridge to Earth. This solution would increase storage and archiving space. At the moment, society has not yet reached the physical limit, so it is not yet a problem, but soon it could become one, and this, again, according to Metzger, could be an essential solution to a problem of tomorrow.

c) Energy:

The space industry could also move power generation off-Earth by building a Space-Based Solar Power system. In the 1970s, this proposal was already made by Gerard K. O'Neil, but the proposal was rejected. Metzger argues that the costs still need to be lowered if we want to create an energy production system with a significant output on a global scale. The potential does exist in theory, but at the moment, the conditions are not suitable for realizing it, and in this sense, Metzger emphasizes the importance of creating an SRSI.

d) Existential benefits:

In this section of the paper, Metzger tries to put space and the realization of SRSI under an existentialist philosophical perspective, questioning how a space economy could affect the future evolution of the human species and what possibilities could be unlocked. Rationally, it tries to appeal to the reader's imagination. Metzger starts from one point: we are on a rock adrift in space, subject to its forces, potentially powerless in the face of fate. That is why the author emphasizes three main points why it would be important to switch to being a multi-planetary civilization: the first is that we increase our chances of survival towards an existential risk (defined as the risk of human existence)

By becoming a multi-planetary civilization, our chances of survival would double. The second point he makes is that once we have colonized another planet, societies will not stop there, and in the near-distant future, humanity could set off in search of distant planets in interstellar space. The third point concerns the logistical use of space for advanced research activities. Metzger uses the example of artificial intelligence for his argument. It is an existential question concerning technological singularity and what will happen when it occurs, i.e., when machines surpass man in intelligence. Many people imagine a despotic future in which machines try to destroy or conquer humanity. In this sense, one possible approach is to conduct advanced research on the subject in a place far away and isolated from Earth, on another celestial body, to proceed more cautiously. The same solution could be tried in studying atomic energy, but the same logistical system could also be applied to other advanced research projects. Metzger emphasizes that to make the science fiction described above a viable future, the construction of an SRSI is indispensable. SRSI, as the author points out, does not require significant developments in the field of artificial intelligence but instead requires a high degree of automation, which we are already developing in factories on Earth.

e) Space monitoring:

One of the essential activities of space from the beginning is terrestrial-monitoring from space. Satellite images are an everyday reality used for infinite purposes and represent one of the primary services space agencies offer to the market. Imagery production and monitoring of the planet is a fundamental activity with multiple applications: from epidemic tracking (i.e., Covid-19), natural resource and land use management, and pollution monitoring, to the latest project on flood monitoring (OECD, 2019). In the future, increased use of monitoring with even more precise data and, thus, more accurate predictions is more crucial than ever. In this sense, the Copernicus satellite system developed by ESA could be just the beginning of a monitoring and forecasting system for future scenarios on a global scale.

What is reviewed in this last part taking from Metzger's (2016) work, is important for underlining the importance of the space sector from a future perspective from a social point of view. Metzger puts much emphasis in his work on the importance of paving a way towards the space economy, creating an SRSI believing that space is more than just an economic possibility.

Mettere view is that space can help solve the bigger problem that society today has: getting closer to the planetary limits. Whether space is a possible path for solving the issue is debatable. However, according to Metzger, the special technological conditions the sector has is an essential part of the research. Thus, it leads to seeing space as a technological incubator. Precisely because of its technical complexity and abstraction, it is interesting to conceptualize the space sector as an 'incubator' of technological innovation, a vast laboratory of technical expressiveness whose spillover effects spill over to all other productive and commercial sectors.

The space sector: a business ecosystem approach

The 'old' space (essentially that of the USA, but not only) was based on a centralized system architecture, which, as we have seen, drew its investments from the public sector. After the last Apollo mission (1972), NASA and thus the US space sector, but more generally the whole industry, struggled to find a second act. Logsdon (2015) described that part of the reason was that the close connection between the Apollo program and the competition with the Soviet Union made NASA's budget vulnerable to the feeling that the mission had already been accomplished. Here the vulnerability of the centralized approach emerges. The vulnerabilities consist of weak incentives for efficient resource allocation, poor aggregation of dispersed information, and resistance to innovation due to reduced competition (Weinzierl, 2018). As mentioned, the Commercial Space Launch Act of 1984 initiated a decentralization of the space sector, leading later to the entry of private parties into the sector. Today, governments are the leading investors in the space environment who through procurement and grant mechanisms, public fund agencies, research institutes, universities, and the private sector (OECD, 2019). As Yuan & Peeters (2019) note, space activities follow a pattern observed with significant technological development. By this phrase, the two authors mean that, initially, these developments are financed by governments based on long-term interests and for political reasons. After the initial investments by governments, companies have used this knowledge and started commercial enterprises.

High-profile entrepreneurs (Musk, Bezos, Branson, Allen, et al.) have used their wealth to overcome high fixed-cost barriers to entry, launching companies based on a new approach to technology and managing access to space (Weinzierl, 2018). Their appearance on the scene gave way to a business approach to the industry, thus creating companies with business models that only make sense when other complementary models are already in place (Weinzierl, 2018). The complementarity gave rise to a business ecosystem approach (Orlova, Nogueira, Chimenti, 2020) which led to a bootstrapping framework toward sector autonomy and reproducibility (Beauvois E. & Thirion G., 2020). The term bootstrapping indicates the initiation of a reproducible process without any intervention outside the system. In short, it indicates an internal reproducibility of a system without external help, a primary goal for a high-cost sector, such as space, to arrive at a similar maintenance equilibrium. What is interesting to note in the literature is that the term bootstrap is found with a particular temporal frequency in various research works over the decades. The first author to emphasize the importance of finding an independent level of reproducibility in the field was O'Neil himself; from there, several have referred to it. Dula A. (1985), Sandler & Schulze (1985), Metzer (2012) (2016), Beauvois & Thirion (2020) all these authors, although with different analyses, stress the importance of an independent bootstrapping system to give reproducibility to the field. Reproducibility is essential for the high costs and the long-term projects that decrease the possibility of revenues in the short to medium term. Further, the bootstrapping of the sector is vital to the innovation processes, giving rise to those spillover effects that Summer (2009) describes in his research.

The space sector is not just about launches, satellites, or exploration. If we look in general at the companies that make up the new space (not only the American context), we can divide the scene into two types of companies: the first is the so-called "low Earth orbit" companies, companies that provide safe facilities for production, research and also tourism (in an altitude between 160-2000 km). The second type is called the 'beyond Earth orbit' companies that focus on space production from asteroid mining to the colonization of the Moon and Mars (Weinzierl, 2018). Returns from investments in space programs take many forms. In the case of space applications, such as telecommunications and earth observation, the main benefits include efficiency gains, cost savings, and cost avoidance. Many of these occur in the following application domains: government services, defense, transport, weather, environmental management, and climate change monitoring (OECD, 2019), but also includes direct consumer applications and personal entertainment (Whealan George, 2018). As mentioned, these broad fields of application have attracted prominent players in the technology industry, making them increasingly involved in space activities (Robinson &

Mazzucato, 2018). In this sense, these prominent entrepreneurs have used an approach to investing in the space market that they have used in other sectors. The private side of the space sector is mainly composed of small or medium-sized companies because of the sector's highly innovative and technological characteristics.

Moreover, small innovative companies focused on "exploration" activities are more capable of doing R&D (Mazzucato, 2013). Small firms, with minimal bureaucracies and flat organizations, are more agile and have more open environments. These environments are more conducive to innovative thinking and research development. Big companies like Google or Microsoft buy these companies to integrate new technologies (Cornell, 2011). This process of privatization of the sector would not have been possible without the help of public intervention. In fact, as both Mazzucato (2013), Weinzierl (2018), Summer (2009), Cornell (2011), but also Reddy (2018), when analyzing SpaceX and its effects on the market, stated that the private sector had given impetus and new dynamism to the sector by inserting it within the global chain.

Nevertheless, with the public funds that have been able to finance long-term projects, and the guarantees that derive from them, it was possible to arrive at the current development. SpaceX, for instance, has received various funding from NASA for various launch contracts (the first one amounting to $396 million for developing its launch vehicle in 2006). Today's space sector is summarized as a context of public funding, with private actors moving within it. For this reason, a change of perspective is needed when analyzing the new space's recent history. The change is because more stakeholders and different actors come together in the context, creating up-down and horizontal linkages. Recent history shows that when emerging technologies impact industries tightly coupled and connected to millions of users, their frontiers can become fluid, and sometimes products, services, and companies cease to exist in this process (Orlova, Nogueira, Chimenti, 2020). As said, it leads Orlova, Nogueira, and Chimenti (2020) to define the space sector using the concept of ecosystem. Following the authors, an ecosystem is a beast network of actors, activities, positions, and links representing does and relations between them. The ecosystem perspective expands the traditional view of an industry by the alignment structure of the multi-lateral set of partners that need to interact for a focal value proposition to materialize. The stability, the authors underline, is provided by "hubs" that have the highest links to other actors, establishing standards and coordinating ecosystem dynamics (Orlova, Nogueira, Chimenti, 2020). Following the ecosystem approach, it is possible to agree with Mazzucato (2013) when she says that looking to innovation is the network that must be analyzed, not the single firm. Creating a business ecosystem that connects all the actors in an interdependent network with the innovative drive is essential to move toward the reproducibility of bootstrapping that several authors mention when analyzing the space sector.

Further insights into the US space sector:

The US was, from the beginning, in a leading position in the space sector. Their history is evident in this sense, but what is the US space sector like today? Furthermore, how has it changed over time?

The US is still the country that is investing the most in the sector (OECD, 2019). As reported by the OECD (2019), the US has a market-leading capability in all space industry segments: space production and launch, operations, and downstream applications. The industry is allocated across the United States, concentrating near high-tech research centers, facilities, and clusters in California, Texas, Florida, New Mexico, Colorado, and Alabama. Several new manufacturing facilities are under construction at the Kennedy Space Center Exploration Park in Florida. The space manufacturing sector comprises several companies with high start-up activity (US Department of Commerce, 2014). In 2019, the US space industry generated approximately $271 billion in revenue (Satellite Industry Association, 2020). Given these generalities, let us take a closer look. Weinzierl (2018), in his work, traces the creation of the modern US space system to the implementation of the Commercial Orbital Transportation Service (COTS). The key innovation of the COTS program was to make NASA a customer and partner of these private contractors. Opening to commercialization has given the industry a commercial approach that opens up contracts to the private sector. Moreover, the shift toward a commercial approach led to new values and concepts in the industry. An example is reusability. The development of the concept was due to lower cost, making it today a central value for space innovation.

COTS contracts created competition in the industry by focusing on which company could provide the best reusability system for its launchers at the lowest cost (examples are SpaceX, Virgin Galactic, and BlueOrigin). The competition is tracked back to the innovative ecosystem Schumpeter talked about, which relates to the concept of creative destruction. Robinson & Mazzucato (2018) argue in their paper that in today's US space system, the mission is to broaden the horizons of space exploration technology by commercializing it. NASA is catalyzing private investment in space infrastructure and services, leading to new forms of procurement to effectively create a market for launches built and operated by the private sector. The authors conclude that the US Space Sector is following the most common path of the new space era, delegating the power to set the directions of the use and construction of publicly funded infrastructure to the private sector, with any profits made resting solely with the private sector. George (2018) describes the American context of the

21st century as a private interest space race, where US policy intended to speed innovation and drive costs down by expanding the role of commercial space companies. Narrowing down, Cornell (2011), in his research when analyzing the American new space of the last twenty years, emphasizes the role that individual entrepreneurs (most notably Elon Musk) have had in shaping the sector today. He argues that the private sector's contribution has given the sector a business approach that has led to two consequences: the search for cost-cutting and a strong emphasis on innovative features. According to Cornell (especially as far as SpaceX is concerned), this has had a secondary effect on the whole sector, namely a valuable young and fresh image. The new image made space again appealing to the new highly skilled and technological workforce. This is why it is appropriate to say a few words about SpaceX. Elon Musk's company is undoubtedly the best-known private space agency operating on the market. SpaceX aims to make humanity a multi-planetary species, intending to colonize Mars shortly (Reddy, 2018). It is a fascinating goal that has created a new buzz in the industry, drawing the company, but the industry in general, back into the spotlight. The effects that SpaceX has caused are not limited to the American context alone but have had transnational effects (Reddy, 2018). SpaceX has brought significant innovations to the industry from a technological (launch and recovery system), organizational/managerial, and 'vision' perspective. From the point of view of systemic implementation in the US context, it is important to underline, as mentioned before, that SpaceX brought a new competition (internal to the US but not only) to the scene. Reusability is a central concept in the commercialization and development of new space, and SpaceX has brought competition in this sense. This competition, guided by state funds, is essential for creating an American space ecosystem so that other entrepreneurs can enter and thrive upon it (Reddy, 2018).

In conclusion, the US has the most developed space sector today. The US space sector has a dichotomous relationship between private and public. A large part of the investment comes from public funds, partly because of the long development times that projects require. The private sector, represented above all by prominent billionaire entrepreneurs, has succeeded in overcoming the initial entry costs, bringing a business approach to the scene, which consequently leads to the creation of an innovation ecosystem with the goal of commercialization of the space.

Chapter 4

Thesis Operationalization

This chapter will focus on the methodological and operationalization aspects of the thesis. Starting it will make an overview of what was sad until this point and how this influenced the methodology and data collection choice. After this, it will explain how the data were collected and related to the framework proposed. Following, expectations are drawn based on theory and concepts. To conclude, the overview description of the gross output matrix on which the interview information is based is presented.

1. Overview

This thesis aims to analyze the emergent space sector. As shown in the previous parts, the space industry has a global dimension in which several different actors (governments, private and intergovernmental organizations) collaborate to develop and explore the possibilities that space enables. Geographically, three main development areas are identified: the USA, Europe, and China. The thesis understands each area as an economic ecosystem in which different entities and organizations collaborate. This part will give a focused analysis of the U.S. space-sector ecosystem. The reason for choosing this area compared to the other two was due to historical and leadership reasons. The U.S. (at that time together with the Soviet Union) was the first to invest and develop space infrastructure, and today is the central player area in the sector.

Much was said about the "new space era," and private companies seem ready to take the sector's lead. However, what relationships create the innovation processes inside the ecosystem? To answer the question, an internal analysis is needed.

The thesis analyzes five elements of the sub-question seen as internal relations: competition, innovation, motivation, collaboration, strategy, and finance. In addition to these five elements, also the role of institutions and centers of knowledge is taken into consideration given their importance for the innovation process as was already argued.

The reason for the choice is that in the present literature, these relationships do not find discussion, nevertheless represent an essential part of the understanding of the sector.

The analysis used for data interpretation is of quantitative and qualitative aspects. The starting point has quantitative elements because numerical values can describe and conceptualize the ecosystem. To do so, an identification of the actors involved and what are the activities of these actors is needed.

For example, an expectation with the first analysis is to find clarifying answers on the role of institutional players like NASA. From this description, preliminary conclusions are made.

A qualitative analysis follows the preliminary conclusions. The function of this second analysis is to clarify aspects of the relationship in which quantitative elements are insufficient for answering: an example, competition's role in the ecosystem and the importance of motivation. The reason for this is due to the abstract and not tangible characteristics that these elements have. For the final conclusions, the results of the quantitative analysis will be questioned through qualitative analysis using interviews from experts.

2. Data methodology and choice:

The first step of the data collection was the identification process. It was essential to identify who was part of the ecosystem. For this, at first, a research of all possible actors involved was made. All the names of companies and organizations that emerged during the literature review process, social media analysis, blogs on the subject, and grey literature as magazines and newspapers were written down. From this process, 49 companies, organizations, plus NASA, and other governmental agencies like the U.S. Space Force, DARPA, and the U.S. Department of Defense emerged as part of the U.S. space ecosystem.

Once detected, the actors were divided into five sub-sections: (a) "Big Three," indicating the three major companies of the economic ecosystem, plus United Launch Alliance, an organization born from the collaboration of Boeing and Lockheed Martin. (b) "Other major companies" refers to organizations with significant roles, dimensions, and revenues in the ecosystem but do not represent the same leading role as the other three. Eight companies are part of this section. (c) "Major U.S. Companies in space-related products or services" in this section included all those companies that do not manufacture or develop technologies directly for space. Still, their market and operations are related to space services, such as satellite communication, data, or broadcast networks. (d) "Entrepreneurial Companies" means all companies privately owned or part of a fund, not present on the stock market. (e) "Extra" in this section presents all those organizations that are not U.S. founded but have a role in the ecosystem, like as strategic partners or present with logistic or manufacturing centers current in the U.S.

From this, a table was made for the collection of data. The data parameters considered necessary are thirteen. From these parameters, it follows a framework with a description of the data and the relationships:

- Sub-sector: meaning that the space sector was divided into six sub-sectors (hardcore manufacture, launch service, satellite communication, data, tourism, flight test service) in which a company operates. In this parameter, companies can have overlaps. This element adds a more detailed description of the ecosystem to the framework, making internal distinctions and focusing on the market-production perspective. Relating this data to direct conclusions can be misleading. This parameter can highlight the ecosystem's major economic activities, and combined with other parameters; it can give insights into the relations questioned.
- Specialization: meaning in what industry is the company specialized as a sub-sector. Specialization, as a parameter, is related to the framework because it helps to define further the role, motivation, goals, competitions, and relations to finance each actor has. The parameter was made to identify possible levels of competition inside the ecosystem.
- Economic activities: meaning what are the services or products that each actor does. Identifying economic activities is challenging because it is difficult to track all the products and projects that big companies do. This data gives an identity to the company, identifying it with a given product or service. The single activity provides insight into the framework and highlights relations inside the ecosystem. It helps to identify the competition and the level of innovation between the actors. The strategy and motivation can also be drawn by looking at the product relations with the institutions.
- Ownership: means what type of ownership is in place and what type of company. Ownership is investigated by tracking the financial and investment parts of the ecosystem.
- Alliance and partnership: according to the framework, collaboration and strategy are essential elements inside an economic ecosystem. This parameter identifies collaborations between organizations inside and outside the ecosystem. This section refers only to private companies; the collaborations with intergovernmental agencies or governmental organizations were collected in different blocks, resulting in five categories: (a) Partnership inside the ecosystem. (b) Partnership outside the space ecosystem but inside the U.S. market. (c) Partnership outside the U.S. market and ecosystem but inside the global space sector. (d) Partnerships that are outside the international space sector and the U.S. market but inside the global market. (e) Not specified.
- Relationship with NASA: as emerged from the literature, NASA is the orchestra of the ecosystem, and for this reason, what relationship an organization has with it is crucial to inquiry. Two are the possible answers for this section: direct relations, not specified.

- Institutions: This parameter aims to clarify which governmental institution a company has relations within. According to the framework, this is essential because institutions are actors who take the orchestra's role. In the data collection, not only U.S. institutions were considered but also international ones.
- The program involved: According to the theoretical framework, NASA is the primary financier of the sector, and NASA programs are the vehicle through which financial contracts are established. Thus, the decision to track all the programs to see what conclusion would emerge. From this, more clarity on the organization's relations inside the ecosystem is expected, as answers on future development.
- The sector of interest: this parameter aims to track the connections between space and other sectors. Moreover, it shows to which sectors space contributes to the development. This parameter is essential to understand better the organization itself and its role and relations in the ecosystem. According to the framework, the importance of these elements is to track spillover effects and understand if the space sector brings its internal innovation components to other economic sectors. This parameter gives insights into co-evolution processes inside the ecosystem, justifying the motivation through the strategy and interest of development. Eight sectors of interest are created: (a) Scientific, referring to space exploration and research activities and developing services for academic institutions and knowledge centers. (b) Government, assisting in civilian government use as data from space observation, earth and urban management, communication infrastructure, and the logistics involved. (c) Communication refers to all services involving satellite communication, from media and broadcast to transportation and the internet. (d) Tourism provides the further possibility of commercializing experience adding space to the sector. (e) Security includes service in the military and security sector by adding space context and technology. (f) Technology manufacturing, applying space manufacturing systems to other innovative industries such as 3D printer technology. (g) Agriculture refers to the data from earth observation transferred to the food and agriculture sector for monitoring and managing food plantations. (h) Commercial/enterprise, with this category, is meant the autonomy of economic activity that a company is developing. If for the other types, space enters the sectors as a possibility of development, with this category are the single space companies that are self-developing themselves without outside demand but enabling the creation of markets.
- Statement of innovation: One object of inquiry is the role of innovation; this parameter aims to record explicit statements about innovation activities for each organization. Two are the

answers: yes and not specified. According to the framework, innovations are a guiding force, and it is important to test the absorptive capacity of the ecosystem.

- Employees: this data aims to understand an organization's dimension based on the number of employees working there. According to the literature, this parameter indicates the number of employees in the sector. If related to the foundation year parameter, it can tell if the industry is growing. Moreover, this parameter can give insight into the connection to knowledge centers, motivation, finance, and strategy of the ecosystem[1].
- Year of foundation: this parameter aims to keep track of the evolution of the ecosystem from a time perspective. This data can be essential to raise questions about the future forecast of the sector as well as confirmation of the growth of it that the used literature states.
- Geographical locations: this parameter is essential to track the geographical and physical locations of the organization. For this parameter is considered necessary to collect data on the location of the headquarters. Relating this parameter to the framework is possible to highlight internal relations between organizations, institutions, and knowledge centers from a geographical perspective.

3. Data collection:

The data were collected by gathering information from internet sources like blogs, social media, and grey online literature such as magazines and news, youtube, and other multimedia platforms (all the sources can be found here [link]). The starting point of data collection is the organization's website and social media, such as Linkedin and Instagram. From the above, it follows a second strategic research using keywords on research engines like google to identify further relevant information.

The data collected is then analyzed by applying a system of points to describe the ecosystem better. The point system aims to clarify the ecosystem's dynamics, highlighting each activity's weight. For instance, inside the category "program involved," if program A has 10 points and program B has 5 points, thus, it is possible to conclude that program A has more significant participation than program B, which can give better insights into the ecosystem and relations understanding. Overlaps explain the choice; for each data category, an organization could have been part of one or multiple. Therefore, the point system is helpful for clarification.

[1] Knowledge centers: relationship between job market in the sector and labor skills;
motivation: the prestige of working inside the space sector for the single worker;
finance: bigger is the number of employees, the bigger is the dimension of the company as volume of capital.
the strategy of the ecosystem: more companies are small, less there are capable of operating in more sub-sector more there is a collaboration between companies, more companies are big more operation capacity they have and more competition is present.

4. Expectations from the data:

This paragraph describes the expectation for each parameter of the data. The expectations are based on the proposed framework, and conclusions are suggested from each expectation.

Sub-sector: for this parameter, the expectations are that the significant economic activity of the sector is hardcore and technological manufacturing. The reason is that according to the literature, space is a sector of technological challenge because of the particular environmental condition in which the technology operates, the complexity of the manufacturing, technological, and operationalization process leading to the creation of the sector infrastructure, and the high cost of access. Direct related to the manufacturing market, there is space accessibility. The space sector, to be efficient, must provide regular and economically sustainable access to space. Without accessibility, space cannot be used and developed. For this reason, launch service, in all its aspects, is expected to be the second economic focus of the ecosystem. According to the framework, other expected important markets are communication satellites, data, and tourism as a growing market.

Specialization: This parameter derives from the sub-sector;
thus, the expectation is to reflect the conclusions of the sub-sector parameter. Moreover, in this parameter, overlaps are expected.

Economic activities: It is complex to draw expectations from this parameter. Based on the sub-sector and a company's specialization, it can be imagined what type of possible product or service it does but not in specific terms. The reason for this is that activities are directly related to each company. Products are expected to satisfy the market sector. Therefore, it is expected to find more hard technological products to realize space infrastructure than other products as soft technologies.

Ownership: three types of ownership are expected, (a) public share, (b) private, and (c) joint ventures. It is also likely to find a correlation between ownership, employee number, and foundation year. According to the theoretical framework, finance institutes, such as banks, and the stock market, negatively perceive funding towards innovative sectors due to the high levels of uncertainty. For this reason, private financing and joint ventures are expected to be the most common types of ownership, confirming the literature review. Public shares or bank participation are not excluded in the sector, but it is expected to find them in companies whose economic activities also take part outside the space sector. The confirmation of this expectation suggests a positive relationship with the theory, implicitly proving the sector's innovative degree.

Alliance and partnership:

Because of the complexity, the high cost, and the several possibilities the sector can offer, a consistent number of partnerships and alliances are expected inside the industry. As stated in the description of the parameter, five categories were made. Different conclusions can be made depending on which types the data prove as prevalent. A high degree of collaboration is likely to present if most partnerships are inside the space ecosystem. Suppose most partnerships are outside the ecosystem but inside the U.S. market. In that case, space is growing in interest in the U.S. market for companies outside the sector.

Furthermore, space development needs the cooperation of organizations outside the sector. Suppose most partnerships are outside the U.S. space sector and inside the global space sector. In that case, the U.S. space sector is an open international sector in which cooperation with foreign partners is seen as positive. If most partnerships are outside the U.S. space sector and the global space sector, space development is a worldwide phenomenon and needs international cooperation. If most partnerships are not specified, the reason is to be inquired, and analysis can still be done with the data at hand.

*Relationship with NASA: T*he expectation is that a substantial number of companies will have direct relations with NASA. Companies classified under not specified do not mean that they do not have relations at all. Besides the effort of searching for data, it is possible to not succeed in finding them, or it has indirect connections as relying on the service of other companies with direct relations with NASA. In both cases, it is expected that this data will suggest that NASA is the ecosystem's central orchestrator; the hypothesis can be proven or rejected by analyzing this parameter by empirical findings.

Institutions: The expectation is to find Nasa as the primary institution that drives the ecosystem. Nevertheless, also other orchestras can be tracked, for example, the U.S. Department of Defense or even international institutions that have relations with U.S. firms. In this case, what must be enquired is if the international institution plays the orchestra's role in the economic activities of the U.S. ecosystem or if they are institutional clients. Depending on the degree that an institution takes part in the ecosystem conclusion about it can be given. If most of the institutions present are research and scientific-oriented, science and exploration are key drivers for the sector's development. If the institutions are financially oriented, commercialization is a key driving force. If military institutions are the majority, the suggestion is that space is a strategic sector from a political and security perspective. The industry has a solid international and global orientation if there is a high presence of international institutions.

The program involved:

During the literature review and the building of the framework, the research material shows that NASA programs play a significant role in the ecosystem; for this reason, it is aspected that an important number of companies will take part in them. Depending on the prevalent program, there are suggestions for the ecosystem's future development. For example, if the most present program is commercially oriented, space will represent an important sector for several markets and the development of their service. On the other hand, if most present programs are explorative-oriented, the suggestion is that the industry is going towards long-term development, in which the focus is not as much on commercializing space services but more on developing space infrastructure.

The sector of interest: The expectation from the analysis of this parameter is that the data reflect in part what sub-sector and specialization parameter concludes. As reported in the literature review, entrepreneurial companies are growing in the sector, thus is expected to find a significant number of companies in this category. Another expected significant volume of participation is in the scientific, government, communication, and security sector. Fewer companies are expected in the tourist, technology manufacturing, and agriculture sectors. For this parameter, overlaps are expected. A positive answer from the data means that expectations are confirmed, thus confirming the suggestions of the literature review. A negative response brings up questions and inquiries about the data and the validity of the literature review.

Statement of innovation: as reported, this parameter is relevant to collect each organization's direct statement of innovation. The truthfulness of the statements must be enquired, but if the statements are true, the following expectations are given. If there is a majority or equal in the numbers, the data are positive and indicate innovation features of the sector and absorptive capacity. On the other side, if there is a significant minority, the data have negative connotations. Negative data do not mean that the sector is not innovative or does not have the absorptive capacity; it means that there is no direct statement from the actors. Thus, other data are to be collected to prove the absorptive capacity of the ecosystem.

The number of employees:

According to the OECD indicators, companies are divided into four categories depending on the number of employees. (a) Microenterprise (smaller than 10), (b) small enterprise (10 to 49), (c) medium enterprise (50 to 249), and (d) large (over 250). This text will also add (e) the mega enterprise (over 25000). Between the categories, there is a ratio of multiple five for passing from one category to the next. Because of the massive difference in the volume of employees for specific companies, it was decided for the category of mega enterprise to use a ratio of multiple one hundred from the large enterprise, thus resulting in 25000.

The expectations are to find a balance in the ecosystem, having most companies fit the medium and large enterprise categories. Suppose, instead, most companies enter the small category. In that case, the description is a segmentation of the sector's operationalization, production, and development, leading toward higher levels of collaboration in the industry. The more the size of the organization's average increases, the more the competition levels in the sector grow. Suppose the majority of companies enter the mega enterprise category. In that case, the expectations are of a high degree of competition, but this is unrealistic because it would mean more than 1225000 people are involved in the sector. To put things into perspective, with only 49 firms, the space sector would have similar numbers to all the employees involved in the farming and related service sector (U.S. Department of Agriculture, 2022).

Year of foundation: according to the literature, two types of firms can be identified based on the year of foundation. "Old space" refers to those companies founded before the year 2000. "New Space" refers to those companies founded after the year 2000. In this context, a differentiation in these categories will be applied to the terms first generation and second generation. First-generation, it is referred to those companies that were founded from the year 2000 to 2009. By the second generation to those companies founded from 2010 to the present. The reason is to track better development and growth of the sector. The expectations are that the new space companies will be the majority of presence in the ecosystem. If the distribution between the first and second generations is more or less equal, the conclusion is that the sector's growth starting from the year 2000 was linear. While if instead the majority of companies are of the second generation, it is data that confirms what the literature suggested, that the space sector is gaining economic interest.

Geographical locations: The expectations for this data are that geographical locations matter in the development of the ecosystem. Further, the expectations are that the organization will locate its headquarters in the proximity of space facilities and institutions. For this reason, the assumption is that a significant number of companies will have their headquarters in Texas, Florida, Virginia, and California. If the data do not answer positively to these expectations, it is relevant to inquire about the reason behind it. In this view, the role of knowledge center, finance, and geographical as physical advantage should be the first to be investigated.

5. Gross output matrix:

From the quantitative analysis, further questions emerged. The thesis uses a qualitative approach based on interviews with experts to answer these questions. This section explains the methodology used from which the information discussed during the interview originated.

The discussion carried out during the interview, with the related information, was based on the gross output matrix based on the statistical data from the U.S. Bureau of Economic Analysis (BEA). "The gross output of an industry is the market value of the goods and services produced by an industry. The primary component of gross output is revenue or receipts, but it also includes commodity taxes, other operating income, and inventory change. […] the statistic is mainly based on gross output by industry" (BEA, 2020).

The statistics comprehend supply-use tables. These tables provide insight into the internal workings of the U.S. economy and detail the contribution of specific industries and commodities (goods and services) to GDP. The supply-use tables detail the flows of commodities purchased by each industry, the incomes earned from production in each industry, and the sales distribution for each commodity (BEA, 2020). Following the BEA (2020) description, the commodities identified as relevant for the data were chosen based on industries identified by the OECD (2012). The relevant products were identified using the Bureau of Industry and Security report (2013).

To conclude, the BEA (2020) defines the space economy with the following:

The space economy consists of space-related goods and services, both public and private. This includes goods and services that:

- Are used in space or directly support those used in space
- Require direct input from space to function or directly support those that do
- Are associated with studying space

Therefore, the information inside the interview also understands the space economy as the above.

Chapter 5

Quantitative and qualitative analysis

This chapter presents the main conclusion from the quantitative and qualitative analysis. The findings reflect the research process. For this reason, the results of the quantitative analysis are summarized and divided into seven sections that represent the seven analytical relationships of chapter 1. On the other side, qualitative research takes a further step, building up on the findings of the quantitative analysis. Therefore, the qualitative study results are summarized and divided into nine sections, each reflecting the interview questions. The extensive process of the two analyses can be found in Appendix A and Appendix B of the thesis.

Quantitative analysis

[Appendix A for all the analysis]

Quantitative analysis conclusion and the seven ecosystem elements.

1. Space ecosystem and competition:

As of today and according to the data, the ecosystem has a positive relationship with the competition. The theoretical framework followed a Schumpeterian perspective of competition, adding innovation as a component. The framework suggested a non-linear relation between competition and innovation; the two elements increase together until a particular level, and innovation decreases by adding competition.

However, from the quantitative analysis description, it is not the case; in the ecosystem, both levels of competition and innovation are rising. This conclusion can be given by looking directly at the sub-sector and specialization parameters, in which a strong interest in technology development is noticed. Other important parameters for the relation with the competition are the ones regarding the relation with NASA and NASA programs. The data suggest that NASA is the principal founder of the sector, founding the sector through programs and delivering contracts, in this way by directing and controlling the development of the sector. Organizations collaborating with NASA compete with each other, making this positive by increasing innovation, development, and quality of products. The sector has important high-tech companies, which is testified by the dimension of the companies when looking at the numbers of employees involved. However, when looking at the years of the organization present, it can be noticed that a significant part was founded in the last two decades. This phenomenon suggests that the levels of competition in the ecosystem are high but with space still available. Given this description, the following question arises: how much competition can the sector afford before getting negative? How much space is there left for organizations from a competition perspective? From a geographical perspective, the data highlighted a concentration of companies in specific areas; looking at competition, what does this suggest? Can competition open new geographical areas for the ecosystem?

2. Space ecosystem and innovation:

The European Commission Green Paper on Innovation (1995) definition was used for defining innovation in the framework. According to this definition, innovation does not only stand on the technical and technological side of an economic ecosystem but also in the management, organization of work, distribution process, increasing of products, and change in the skills needed for the workforce. The entrepreneurial shift in the sector as the most diffuse economic activity supports the view of innovation as ongoing in the sector. Following this view, the data collected shows that innovation is an ongoing process inside the sector. The process is not only in the technical and scientific components of the ecosystem but even more in the development of all those elements that create the technical outcomes and scientific knowledge needed for development. In support of this statement, an example is conclusion 7 (in Appendix A).

Further, the framework has suggested the concept of emergent innovation understood as knowledge at work (Peschl & Fundneider, 2008). The authors offer a six-point framework for predicting emergent innovation based on knowledge. By applying the six points to all the ecosystems, it can be seen the framework at work. The first point of the framework is to acquire knowledge. The process was made during the space sector's start, in the "old space" period when NASA and the oldest companies were starting the sector. Today, by observing the sector's development through the space programs proposed by NASA and the increasing number of companies in the last two decades, it can be stated that the sector is at point six of the framework (generated knowledge embodied in the ecosystem). The sector funding is another element that suggests a strong presence of innovation. The data show a low presence of banks; the most significant investor is NASA or, better put, the US government.

Further, as reported in conclusion 5 (in Appendix A), most companies are privately owned, meaning they have a relatively small presence in the stock market. This conclusion can be explained by following Mazzucato's ideas, in which the scholar suggests that the high uncertainty of innovation makes banks and big finance organization not interested in the investment for the high degree of losing profits due to uncertainty. The last point of conclusion regards the flow that innovation follows inside the ecosystem. In the framework, Kollar (2015) uses work against the classical view of innovation as a bottom-up process, stating that innovation is multi-directional. The data collected confirms the perspective. The description that it offers makes innovation an up-down process (as NASA plays a role), bottom-up that are directly the companies that stimulate innovation, as well horizontal trajectory because there is a transfer of knowledge and practice between companies. The transfer of knowledge and practices play create an epistemic community in the space sector (more about it in point 7). From the description, a question arises: at what point of the innovation process is the space ecosystem? When will banks and finance organizations enter the sector with meaningful participation? When this happens, will the level of innovation and its relation in the sector change?

3. Space ecosystem and motivation:

Motivation is a challenging relation to measure. From the framework created, three elements were given to track the relation inside the ecosystem:

1. variables that affect the stream of behavior,
2. nomological networks of the relationship between variables,
3. the consequences of motivation related to future behavior).

Applying this framework to the data and giving materiality to the relation, it is possible to say that the institutions with a significant presence stimulate the motivations inside the ecosystem. The institutions represent the variable that affects the behavior inside the ecosystem, as well as the institution set down the nomological relations. Through their behavior, the prediction of future consequences is shown, and it is obtained the inquiry of motivation passes from the institutions. The data show that the most prominent program for NASA is Artemis, so the motivation is to bring America back to the moon. Artemis suggests that the US wants to use Moon resources, but this raises questions on the international agreements regarding the use of space. Under the same perspective, the US Department of Defense is the second institution present in the ecosystem. However, in the international agreements on space in use, it is stated the no use of space for military activities. Nevertheless, looking at the data, much rhetoric is made on the opening of space and the possibilities for a broader public, viewing public institutions as financing the realization of the infrastructure needed. Nevertheless, the further question should be moved towards the motivation of these two leading institutions, trying to understand how the US Government views space.

4. Space ecosystem, collaboration, and strategy:

The theoretical framework states that collaboration and strategy are linked to motivation. According to the description provided by the data, the strategy that the ecosystem follows is that institutions create guidelines issued as programs that later private companies will follow to get a contract to finance themselves and develop. Collaboration is highly present in the ecosystem, proving conclusion 6 (in Appendix A). Organizations collaborate to develop the requirement of the programs set by the leading institutions. The data show that the sector is growing, following, a question arises: what impact will it have on the growth of the sector on the strategy? The institutions will always be the orchestrators, or the leading roles of the ecosystem and strategy will change? Following this perspective, the data show the advent of the Google Lunar X Award. Is this a radical change in strategy or not?

5. Space ecosystem and institutions:

The theoretical framework suggested an analytical relation between the ecosystem and the institutions in which the latter would play the role of orchestrator inside it. The data analysis confirmed the description. The analysis reveals that NASA is the central institution in the ecosystem, followed by the US Defense Department. Nevertheless, the US Defense Department acts more as a financier of the sector, leading to developing technology. In that case, NASA directly shapes the ecosystem by making guidelines and programs with grants to develop the sector. In fact, from the data, it can be noticed that a high number of companies have direct relations with NASA, and those that do not have it directly, have it indirectly (as was already described). On a geographical level, it was seen that the institution's site (above all, NASA) and its facilities influence the location in which companies locate their headquarters. This result is evident when looking at states like California, Virginia, and Texas with the numbers of space companies in the region.

Besides this, still, the questions remain unanswered. For instance, the role that educational and scientific institutions have in the ecosystem still needs to be determined. The data collected shows the presence of scientific and governmental institutions for weather forecast and ocean monitoring, but they have a small involvement in the ecosystem. Even less clear is the role that universities play in the ecosystem. In the data collection, the presence of universities (the US and international ones) was founded, but less than the first expectation. It also needs to be determined if the universities' common practice is directly financing companies or if they pass from NASA or another orchestrator in the ecosystem. From this perspective, more research is needed to make it clear.

6. Space ecosystem and finance:

The literature review discusses in depth the relationship between finance and innovation. The relation is central to the thesis. In the framework, it was suggested that the finance sector negatively perceives financing innovation activity due to the high uncertainty that innovation has intrinsically inside it. It was expected that most companies would be privately owned or financed by joint ventures and capital funds. The presence of financial institutions, banks, and the stock market was not excluded completely, yet it was expected to be a minority and related to the mega-entrepreneurial companies. The data confirmed the expectation, given that the most common type of ownership is private (conclusion number 5 in the Appendix). This conclusion implicitly suggests the description in point 2 (the relation between the ecosystem and innovation). Looking at the numbers of employees for each company, it is possible to notice that most companies have less than 500 employees, suggesting that they are big-entrepreneurial companies but not mega-entrepreneurial. This element also suggests what was described in the literature review section, arguing that companies more circumscribed and privately owned have less obligation and concern towards investors and can dedicate themselves to more explorative activities bootstrapping innovation. According to this description, the positive explorative activities are transferred and acquired by big companies that commercialize them for the big market.

Following the financial analysis, the space sector follows this internal process, so a positive relationship between finance and innovation in the ecosystem can be drawn. In general, from the quantitative analysis, what emerges, is a vertical finance structure. Companies are privately owned, and NASA, the orchestrator of the ecosystems, creates programs inside the ecosystem. Companies apply to these programs to get grants and contracts with NASA. The type of finance is vertical because NASA creates spillovers of its budget to finance investment and develop the ecosystem. From this perspective, questions follow: the growth in the sector would change the type of finance and the ecosystem's structure? If the type of finance changes, will the role of NASA also change? Are there other strategic reasons behind the modality of private ownership?

7. Space ecosystem and center of knowledge:

From the quantitative analysis, it needs to be clarified what the relationship is between the space ecosystem and knowledge centers. The data collected show that scientific and explorative are essential activities of the ecosystem, yet a small presence of universities was found. As stated, not only universities are knowledge centers; as argued in point 5, specific categories of governmental institutions can be understood as knowledge centers, including NASA. Considering this, a critical conclusion can be made when looking at the geographical locations of the ecosystem. As already argued, space facilities have a degree of influence when looking where to position a company. Knowledge, in this perspective, has a role. The facilities do not play a role only on a material and technological level but also in knowledge creation and transmission; in this sense, the conclusion suggests that this cluster can give rise to what we call epistemic communities. These communities, as part of the same sector and speaking the same epistemic language[2], can promote positive relations between knowledge centers, companies, and collaboration, suggesting that geographical location plays an essential role in the ecosystem.

As stated, this conclusion is a partial one; questions still arise. For instance, universities' role in the ecosystem and think-tank organizations must be clarified. A more detailed analysis from this perspective is needed.

Qualitative analysis

[Appendix B]

The function of the following section is to give the reader the main findings of the qualitative study in a concise manner. In the next chapter, these findings, together with the quantitative analysis and the literature review description, are discussed using a triangulation approach.

1. Contextualization of the U.S. Space Sector:

Inside the U.S. Space Sector, it is possible to create a distinction between two broader categories of actors: the private and the public. Private companies are more interested in market-related activities such as commercialization, thus finding extensive participation in service. On the other side, public organizations are interested in government activities for the state as defense applications.

Looking at the industries inside the sector, the biggest one is manufacturing hard-technologies such as satellites and rockets. The second biggest industry is information as communication and broadcast, thus related to service.

2. Relationship between NASA and the Department of Defense:

The military and defense are a pretty extensive part of space. But what is essential is that every institution has its functions and interest, meaning that NASA and the Defense are independent.

[2] I.E., in the sense of knowledge, language, and practice related to the development of space activities and research

3. Banks in the U.S. Space Ecosystem:

Banks play a role in the sector because of the need for insurance. Relating to investment, however, banks do not play significant roles because they are risk averse, thus making it less likely for a bank to give money to companies for activities with a high degree of uncertainty.

4. The role of universities in the U.S. Space Ecosystem:

Universities play an essential role in the development strategy of the U.S. Space ecosystem. Universities are considered federal centers for R&D, and most of the funding comes from NASA or the Science Foundation.

5. Epistemic communities inside the U.S. Space Sector:

The Space Sector is a small community; thus, people already inside it start new companies and activities. From a geographical perspective, already existing infrastructure, space facilities, knowledge centers, and epistemic clusters influence the choice of a new plant.

6. The motivation of the U.S. Space Sector:

The motivation inside the U.S. Space sector can be read from a cultural perspective. Moreover, this way of reading is connected to the bigger "American Dream." Thus, according to the interviewees, the motivation in the U.S. Space sector is a phenomenon that derives from the broader American culture.

7. The strategy of the U.S. Space Sector:

The interviewees were asked if the realization of private space programs as the Google Lunar Award is a paradigm shift in the sector. For the interviewees, the Google program is not a paradigm shift in the sector, but it is a signal of the importance of the space sector in the U.S. Economy.

8. Competition and regulation inside the U.S. Space Sector:

From a regulatory authority perspective, the primary role of the government is to collect taxes. But it also has regulations concerning safety measures and responsibilities regarding what can go in space and insurance. However, when it comes to competition and regulation, the choices of suppliers are up to the single company or organization. Thus the government does not have a primary role in this sense.

9. The processes of innovation inside the U.S. Space Sector:

Government agencies such as NASA, the Space Force, and the Department of Defense are encouraging private commercial companies to enter the sector because privates are more efficient in creating innovation than publicly owned organizations due to a lower degree of bureaucracy. From this, private companies try to innovate even more to get government funding, so this ecosystem structure stimulates the innovation process. It follows a distinction between private companies. Big companies, such as Boeing, Lockheed Martin, and SpaceX, make most of the commercial products; however, small companies are part of the ecosystem. Most of the time, small companies go bankrupt or get absorbed by bigger ones, thus stimulating knowledge transfer and related innovation processes.

Chapter 6

Findings and results

This section discusses the work made until this point. The research uses multiple and mixed methods. Thus, it requires the testing of each result from the different methodologies. The testing is made through a discussion based on triangulation. Triangulation is a helpful methodology for capturing the complexity of real-world phenomena (Heale & Forbes, 2013). The complexity is captured by varying data and methodologies, gaining multiple perspectives. A discussion of the findings based on triangulation increases the credibility and validity of the research (Bekhet & Zauszniewski, 2012). Credibility is about the content. It is given by how confident you can be that the findings reflect reality. This is possible by how much the findings converge or agree with each other. Validity is about the methods. It is how accurately a method measures what it is supposed to measure. Triangulation is an effective way of discussion because by combining methods it is possible to compensate where there is a lack and strength for each methodology.

The thesis uses three different methodologies: the literature review, the quantitative analysis, and the qualitative analysis. The findings are related to the five sub-questions, and to insights on innovation offered by the three methodologies (question 6 below). Each methodology has its own related findings; therefore, in this chapter, each finding is put into relation and dialogue with the related two, leading to answers.

The discussion shows the credibility and validity of the findings. After this process, all the elements for answering the main research question of the thesis are in place. Thus, conclusions are drawn.

In order to track the information of the findings inside the research, this chapter uses a reference system. This system allows the reader to navigate and follow the chapter's discussion better. The symbol (p.[…]) indicates the page where the information is inside the thesis.

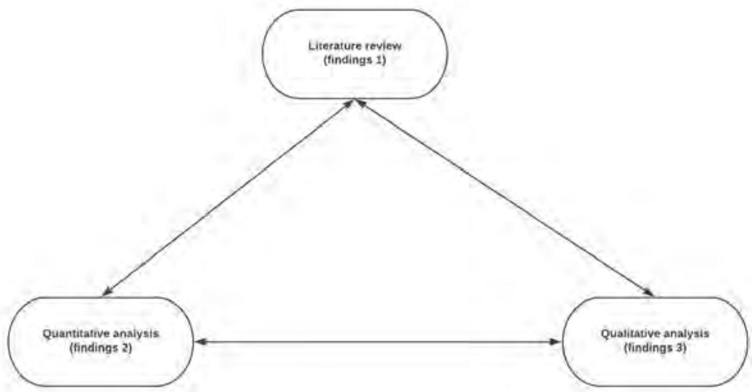

Figure 2. Triangulation analysis scheme (made by the author)

Findings and discussion

This section answers each sub-question presented at the start of the thesis. The questions are answered by using the three different findings from the three methodologies. After reporting the three findings, a discussion around them is made. The discussion will then lead to the final answer to the question.

Sub-question 1: how does motivation inside the U.S. Space ecosystem influence the innovation process?

Findings 1:

Motivation is a problematic element to track in the literature. Material on the subject and its analysis were not found while building the theoretical framework and the literature review process.

Thus, there are no clear findings from this perspective. It is possible to construct an answer based on the bigger picture of the sector described by the academic material. Looking at the history of the U.S. Space sector is plausible to say that space is part of American culture. The suggestion is given when looking at the story of the "old" space and the significant impact and related narrative that the men-on-the-moon race gave to all American culture (p.23). This first suggestion is summed up and shown by the classical children's dream of being an astronaut (p.111 in Appendix B). Culture is not the only element.

In the literature review, there are several statements about the economic importance of space for the future economy. The OECD 2019 report summarizes the findings, describing space as a major economic driving force (p.25). The possibility of profit that the "new" space has is the main economic motivation actors have to invest in and develop the sector. Several government actors institutionally translate this motivation. Chronologically the first is the 1984 "Commercial Space launch act" signed by President Regan, while the latest one is the 2015 "Commercial Space launch competitiveness act" by President Obama (p.26). Another essential element linked to motivation is the visionary possibility that space offers to the future. The research shows this side of the sector using the work of Metzger (2016), and more in general, is the type of narrative that prominent entrepreneurs such as Musk use to justify their interest in the Space sector (as the colonization of other planets) (p.30). Thus, from the above, the conclusion is that from the material in the literature review, three elements make motivations: culture, the possibility of profit, and the visionary dream of shaping the future. The first element explains America's general interest in space as a nation. The second explains why the space ecosystem has been growing in recent decades. The third explains the interest of prominent entrepreneurs entering the sector. Whether that interest is towards themselves or, as they state, towards humanity is debatable.

The first findings see motivation as a positive force that actively shapes innovation. The origin of motivation is to find it inside American culture, but the other two elements are the ones that shape the innovation process. Thus, motivation shapes innovation in the short term according to the possibility of profit. In contrast, in the long term, innovation is shaped by motivation according to the visionary dreams of those with the capital to finance the sector combined with the tangible project that government agencies create through space programs such as Artemis of NASA.

Findings 2:

Motivation is a challenging relation to measure. From the analytical relation created, three elements were given to track the relation inside the ecosystem ((i) variables that affect the stream of behavior,

(ii) nomological networks of the relationship between variables, (iii) the consequences of motivation related to future behavior) (p.7). Applying this analytical perspective to the data giving materiality to the relation, it highlighted that the institutions with the most significant presence are the ones that stimulate the motivations inside the ecosystem. The institutions represent the variable that affects the behavior inside the ecosystem, as well as the institution set down the nomological relations. Through their behavior, prediction of future consequences is possible. The result is that the motivation inquiry passes from the institutions. The data show that the most extensive program for NASA is Artemis, so the motivation is to bring America back to the moon (p.95 Appendix A). This suggests that the U.S. wants to use Moon resources, but this raises questions about the international agreements on the use of space. Under the same perspective, the U.S. Department of Defense is the second institution present in the ecosystem. However, in the international agreements on space in use, it is stated the no use of space for military activities. Looking at the data, much rhetoric is made on the opening of space and the possibilities for a broader public, viewing public institutions as financing the realization of the infrastructure needed. However, the further question should be moved toward the motivation of these two leading institutions to understand how the U.S. Government views space. Thus, the empirical work shows institutions' importance in guiding the motivation inside the U.S. Space ecosystem (p.102 Appendix A). This importance is directly related to the innovation process. Suppose the institutions guide the level of motivation by tracking the road through space programs. In that case, they also track the direction of innovation by establishing the big picture and the long-term horizon. Nevertheless, according to these data, the specific way of innovating and developing a single technology or practice is up to the single company or organization.

Findings 3:

In the qualitative section of the research, it emerged that two different stories give the motivation inside the U.S. Space sector. On one side, this popular view of space as an American symbol of discovery and technological advancement. On the other side, space is a business opportunity that finds its symbol in the entrepreneur. Both elements are part of a more considerable aspect of American culture, in which the narrative focuses on the single individual and their will for discovery. The importance of discovery locates itself in a more general historical view and continuity of American culture. This aspect reminds a historical connection: in the XIX century, pushing the discovery towards the west and now looking at the stars (p.112 Appendix B). Nevertheless, the research does not have enough arguments to support these findings.

The qualitative research highlighted the shared motivation inside the U.S. Space community. The shared motivation is a positive element relating to the innovation process. Suppose the motivation is shared, then also the view of the bigger picture towards where to draw space development. Thus, the innovation process will benefit from it.

Discussion:

The research has produced three findings regarding motivation inside the U.S. Space ecosystem. Findings 1 and 3 have located the origin of the motivation of the U.S. space community inside the more general American culture. Findings 2 highlighted the importance that institutions have in guiding the motivation of the community into strategy, thus, putting motivation into practice. Findings 2 are supported by findings 1, in which there is a reference to space programs' importance in making motivation become a practice. What the research does not do is a deep inquiry and analysis of motivation as part of American culture.

Further, findings 3 refer to "space community," while findings 1 and 2 to "space ecosystem." Between the two, the difference might be slight; however, a clear definition during the collection should have been given. From the above, the conclusion is that findings 1 have shown two aspects of motivation (the origin in culture and the translation of motivation into practice thanks to institutions). The two aspects are then reflected respectively by findings 3, relating to culture, and findings 2 relating to the role of institutions.

Answer:

The origin and translation into practice of motivation are what emerged during the discussion. If the original location of motivation is in the more general American culture, the institutions that are part of the ecosystem are those that channel it into practice. The conclusion is that motivation influences the innovation process by how institutions can channel it, translating it into practice.

Sub-question 2: How does the strategy that the U.S. Space ecosystem follows influence the innovation process?

Findings 1:

From the literature review used in the thesis, it is possible to say that long run strategy of the U.S. Space sector was to make a transition from the centralized system, which was the "old" space, to a decentralized one, that is, the "new" is space today (p.34-35). The OECD reports emerged that government is the principal investor in the U.S. context (p.25). The investments are made through grants and space programs in which the funds flow through public agencies, research institutes, universities, and the private sector (p.37). According to the review, the private sector is increasingly becoming important (p.34-35). This increase led to a business approach to the space industry. What emerged was the need for a bootstrapping reproduction system of the sector (p.34), meaning a degree of reproducibility leading to autonomy. For aiming to this position, the strategy found is that NASA, the central orchestrator of the ecosystem, creates space programs with grants and contracts (p.36). The creation of space programs raises the level of competition between companies, pushing innovation. The review emerged that most companies that compete for NASA programs could be considered "big" companies, the leaders in the sector (p.36). Therefore, these companies financed by NASA space programs are the ones that build the hard core of the space infrastructure. The reason that justifies this is the high cost of entry. Once the entry costs and infrastructure are made or are making progress, smaller companies, or companies interested in the service opportunities that space offers, start to enter the sector and make their economic activities (p.33-34). These findings conclude that the collaboration between the private and public sectors is the strategy followed by the U.S. Space sector (p.35).

In answering the question, the findings suggest that the strategy influences the innovation process by giving the role of creating the agenda and the destination to the government. However, zooming into the agenda, the private sector creates the way to arrive at the destination. Furthermore, the reason for this is that the public can take care of the possible risk and uncertainty of the investment, a factor that would be impossible for the private (p.35). On the other hand, the private sector, with its less bureaucracy, can give that flexibility and dynamism that the public would not have (p.35). Of course, in the real-world scenario is plausible that the two elements co-shape one another.

Findings 2:

The conceptual model represents that the strategy emerges from the interaction between motivation and competition (p.12). The empirical analysis shows that the ecosystem's strategy is that institutions create guidelines issued under the form of space programs that later private companies will follow to get access to contracts to finance themselves and develop (p.95 Appendix A). An important finding that the empirical research on the strategy has shown is the high presence of collaboration in the ecosystem (p.98 Appendix A).

Collaboration is an element that was not taken into account at the beginning of the research. Relating the new element to the strategy is deduced that companies inside the ecosystem collaborate to develop the requirements of the space programs set by the leading institutions. The data also show that the sector is growing in the volume of activities (p.91-93 Appendix A). These activities refer to the innovation process as well. Thus, from the empirical work, the strategy's influence on the innovation process is the following: the strategy creates an up-down flow of capital channelized inside the space programs. Companies' response is to use innovative practices and technology to answer the request for space programs. Therefore, making the innovation process a bottom-up trajectory.

Findings 3:

Three sections of the qualitative section of the research are relevant to this finding.

The section "contextualization of the U.S. Space sector" (p. 110 Appendix B) reports the difference of interest between the private and public sectors inside the space ecosystem. The section shows the relationship that is going on between the two different social parts. The private is interested in developing space for market ends, while the public is interested in government activities. The two are not separate; they are co-dependent and co-evolve. The second section, "strategy of the U.S. Space sector" (p.113 Appendix B), posed specific questions to the interviewees to clarify quantitative analysis findings. It was asked if the creation of private space programs was to be considered a shift for the sector. According to the interview, it is not the case but proof of the ecosystem's strategy. This one rotates around creating programs from which companies can make contracts and win grants. The creation of private programs is proof of the increased commercialization that space is getting from the economy. The third section is related to "the role of the university in the U.S. Space ecosystem" (p.112 Appendix B). This point zooms into the strategy. It highlights the strategy that the sector uses for explorative innovation. One of the main strategies reported is to send money to universities and have college students explore a particular idea's potential. This process is considered an important strategy that applies to innovation inside the space ecosystem.

Discussion:

The three findings share the general view that the interaction between the private and public sides of the sector results in the bigger industry strategy. All three agree on the co-dependence and co-evolution that is in place between the two social parts. Further, each finding adds information to defining the strategy. Findings 1 explains why the strategy evolved in today's direction and the steps made. Findings 2 show how the strategy increases the level of collaboration in the sector. Findings

3 highlighted the role of universities in the space industry's innovation strategy. All three findings also agree that the sector's strategy is guiding it towards bigger commercialization and decentralization compared to the past. What is problematic about these findings is that besides the shared view of the strategy between private and public, the other results still need to be confirmed by the other findings. Each type of analysis ends without confirming or rejecting. This fact is something to consider when reflecting on the validity of these results.

Answer:

The discussion emerged that the strategy is a mix of interaction between the public and private sides of the sector. The government creates the guideline, while private companies follow them to get contracts. This influences the innovation process by increasing the level of collaboration between organization inside the ecosystem. However, the analysis also shows that a vital innovation strategy is to stimulate innovative exploration through universities. The reason is to make students do the preliminary explorative activity to save investment costs.

Sub-question 3: How does competition inside the U.S. Space ecosystem influence the innovation process?

Findings 1:

Competition is a complex parameter to measure. This research does not try to quantitatively and qualitatively measure competition in itself in the ecosystem but tracks its relation with the innovation process. By defying competition, in the analytical section of the thesis, it was said that conceptually competition is founded under two spheres: the macro and the micro (p.9). Further, when linking it to innovation it was said that between the two there is a non-linear relation that gives; as a result, a U-shape relation (p.10). This type of relationship means that innovation and competition increase until a critical point and the two elements decrease. Inside the literature, we are looking for findings on these elements. The section "space sector: a business ecosystem approach" (p.33-34) says that the increase of stakeholders created up-down and horizontal linkages.

The research material suggests that both types of competition are founded on these linkages. The macro, defined as the general advantage-seeking on the market, is founded inside the space programs and their grants. The macro is linked with the strategy of the ecosystem. As was previously said, the ecosystem's strategy is to create space programs (usually founded by the government) in which private companies compete to get contracts or grants. However, competition changes at the micro level compared to the macro level. The creation of patterns between the actors for business development gives the change. The literature shows that the presence of hubs in the ecosystem creates the structure of the competition pattern. Hubs have a high presents of links aligning the structure and the dynamics of the business network. The two above suggest that competition inside the U.S. Space ecosystem is not a force that isolates actors, but it is proactive due to the creation of linkages and collaboration. Competition is proactive when linked to innovation. The reason is deduced by the fact that the less bureaucracy of private firms makes them more dynamic for the innovation process, and the creation of patterns suggests a rise in capacity. However, when relating to the U-shape relation needs to be clarified, using the literature material, where is the critical point of decrease.

Findings 2:

As of today and according to the data, the ecosystem has a positive relationship with the competition. Chapter 2 suggested following a Schumpeterian perspective of competition, adding innovation as a component (p.14). The framework suggests a non-linear relation between competition and innovation; the two elements increase together until a particular level, and then innovation decreases by adding competition. According to the quantitative analysis description, the non-linear relation is not the case, and both competition and innovation are raising their levels inside the ecosystem. The conclusion is given by looking directly at the sub-sector and specialization parameters (p.91-93 Appendix B), in which there is a strong interest in technology development. Other important parameters for the relation with the competition are the ones regarding the relation with NASA and NASA programs (p.95-100 Appendix A). The data show that NASA is the primary founder of the sector, founding the sector through programs and delivering contracts, in this way by directing and controlling the development of the sector. Organizations collaborate with NASA and compete with each other, making this positive by increasing innovation, development, and quality of products. The sector has important high-tech companies testified by the dimension of the companies when looking at the numbers of the employees involved (p.104 Appendix A).

Nevertheless, when looking at the years of the organization present, it can be noticed that a significant part was founded in the last two decades (p.105 Appendix A). This shows that the levels of competition in the ecosystem are high but with space still available. The analytical relation section highlighted the U-shape relation between innovation and competition from the work of Kamien & Schwartz (1976). The empirical work supports this relation only partially. This is because the data show an increase of both elements, but there is no suggestion of the possible critical point and related moment of decrease. From the above, the findings of the quantitative analysis show a positive correlation between competition and the innovation process in today's U.S. Space ecosystem.

Findings 3:

The qualitative section of the research looks at the relationship between regulations and competition. The findings highlight that the government does the regulatory aspects of the sector. The research shows that the regulatory activity of the government is to collect taxes and safety/ responsibility measures for what can go into space. Therefore, the findings show that the government has no top-down regulation in regulating competition inside the ecosystem (p.113 appendix B). The government's no participation in the sector's competition aspect results in that competition in the industry is free from regulation, thus, locating competition between companies. Concerning the U-shape relation between innovation and competition from Kamien and Schwartz (1976), no supporting findings resulted from the research.

Discussion:

The three findings approach competition under different aspects. The different approaches identify two types of competition directions. Findings 1 and 2 support the view of a top-down competition direction. Findings 1, 2, and 3 support the view of a horizontal competition direction. Findings 3 does not support the top-down direction of competition because it argues that government does not apply regulatory activity in limiting competition. This result does not contradict the top-down direction funded by the other two findings. There is no contradiction because top-down in this context refers to the competition to achieve grants and contracts by government institutions. Thus, the no-regulatory activity that the government has for the competition is still valid. Findings 1 suggested a pattern structure of competition on the micro level. Findings 2 do not prove or reject it. Findings 3 supports this by locating a deregulatory form of competition between companies leaving open the possibility for pattern structure. The three findings show that competition and innovation are rising in the sector. The analytical relation section argued for a U-shape relation between innovation and competition. However, no critical point was identified; thus, there is no confirmation of the U-shape relation.

Answer:

The results show that competition does influence the innovation process. Both elements are rising in the ecosystem of the sector. Today there is a positive relationship in play, but the research does not show if the relations will stay positive over time. When locating competition, the research shows that it has a horizontal dimension, thus positioning it between companies. Moreover, competition stimulates innovation in horizontal linkages maintaining a top-down understanding of the sector.

Sub-question 4: How does the organization of the U.S. Space ecosystem influence the innovation process?

Findings 1:

The transition from a government to a market-oriented sector highly influences the organization of the U.S. Space ecosystem and the innovation process that the organization structure allows (p. 23-24). Inside the research material used for the literature review, there are several indications of the change in the organization of the ecosystem. The first indication is when looking at the institutional description of the sector. In that section, a series of documents are mentioned that regulate the U.S. Space sector (p.26-27). Those documents show the transformation from a public-driven sector to one with significant private participation. In the section "space sector: a business ecosystem approach" (p.33) is reported that an important reason for the change of the organizational structure during the transit from the "old" space to the "new" space was the risk of vulnerability that the centralized organization of the "old" space had. The vulnerabilities were three: weak resource allocation incentives, information dispersion, and innovation resistance. The origin of the vulnerability goes back to the achievement of the men-to-the-moon mission (i.e., the end of a clear goal). The change of organization made it possible to enter the sector of private companies. According to the research material, this gave new momentum to the sector. Looking at the conceptual model (p.12), organization results from the interaction of four different elements: competition, motivation, strategy, and finance as an inter-contextual element. These elements fit the more general view of today's business approach to the sector, creating companies with business models that make sense when complementary to other businesses.

The type of organization that the ecosystem follows, shown by the literature review, is one of interaction between public and private (p.36). The U.S. Space sector is summed up as a public context with private economic actors. The OECD report (2019) has shown that the government is the more prominent investor in the ecosystem (p.36). Thus, suggesting that NASA is the orchestrator of the sector. Moreover, the answer to sub-question 2 supports the above. Through the creation of policies, government agencies set the space programs (and so the direction of development of the sector). On the other side are the private companies that produce the technology using the government as the primary client to build the infrastructure and the technology needed for the sector.

Looking at the organizational aspects of the sector from a geographical perspective, several are the locations of the industry across the U.S., creating research centers, facilities, and clusters (p.36). From these findings, it follows that the organization of the ecosystem strongly influences the functioning of the innovation process inside the sector. Cornell (2011) has argued that the transition toward a business approach in the sector has led to two more significant consequences: the first, the search for cost-cutting, and the second, the search for innovative features (p.37). Both elements would only be possible with a change in the organizational structure of the ecosystem. The suggestion that prominent entrepreneurs could overcome the industry's entry cost thanks to their capital is plausibly valid.

Nevertheless, the possibility to enter the sector was made possible by a change in the policy regulating the sector (the 1984 Commercial Space launch act is an example) (p.26). The change originates in the government, leading to the decentralized structure that characterizes today's organization. From the material used in the literature review, the conclusion is that the ecosystem's organizational structure stimulates innovation inside the sector thanks to the degree of freedom given to the private sector and related economic activities.

Findings 2:

Based on empirical work, the quantitative analysis divides the concept of organization into two elements (institutions and centers of knowledge). The description and explanation of the two elements are in the key concepts and analytical relation section (p.10-11).

a) Organization-institutions:

The analytical framework suggests a relation between the space ecosystem and the institutions in which the latter plays the role of orchestrator (p.11). The qualitative analysis confirmed the description (p.89 Appendix A). The analysis reveals that NASA is the primary institution in the ecosystem, followed by the U.S. Defense Department (p.101 Appendix A). However, the two governmental institutions operate differently. The U.S. Defense Department acts more as a financier of the sector, leading to developing technology. NASA instead directly shapes the ecosystem by making guidelines and programs with grants to develop the sector. In fact, from the data, it can be noticed that a high number of companies have direct relations with NASA, and those that do not have it directly have it indirectly (as was already described) (p.100 Appendix A). On a geographical level, it was seen that the institution's site (above all, NASA) and its facilities influence the location in which companies locate their headquarters. This result is evident when looking at states like California, Virginia, and Texas with the numbers of space companies in the region (p.106 Appendix A).

Besides this, the question still needs to be fully answered. For example, educational and scientific institutions' role in the ecosystem still needs to be answered. The data collected shows the presence of scientific institutions founded by the government for weather forecast and ocean monitoring. However, it seems that they have a small involvement in the ecosystem. Even less clear is the role that universities play in the ecosystem. In the data collection, universities (the U.S. and international ones) are founded, but less than the first expectation. It also needs to be made clear if the universities' common practice is directly financing companies or if they pass from NASA or another orchestrator in the ecosystem. From this perspective, more research is needed to make the findings more transparent.

b) Organization-center of knowledge:

From the quantitative analysis, there is a need to clarify the relationship between the space ecosystem and knowledge centers. The data collected show that scientific and explorative activities are essential activities of the ecosystem, yet a small university presence was found (p.58). Universities are knowledge centers, and specific categories of governmental institutions can be understood as knowledge centers, including NASA (p.111-112 Appendix B). Considerating this, an important conclusion is made when looking at the geographical locations of the ecosystem. As argued, space facilities have a degree of influence when looking at where to position a company (p. 108 Appendix A). Knowledge, in this perspective, has a role. The facilities do not play a role only on a material and technological level but also in knowledge creation and transmission; in this sense, the conclusion suggests that this cluster can give rise to what we call epistemic communities (p.52). These communities are part of the same sector and speak the same epistemic language (the knowledge and practice related to the development of space activities and research), promoting positive relations between knowledge centers, companies, and collaboration, suggesting that geographical location plays an important role in the ecosystem.

As stated, this conclusion is a partial one; questions still arise. For instance, universities' role in the ecosystem and think-tank organizations needs to be clarified. A more detailed analysis from this perspective is needed.

Linking the above together and relating it to the innovation process, we obtain that how organization is designed and structured actively influences the innovation process. The empirical data from the quantitive analysis support that the government decides the blueprint for the sector's development realized through the organization (p.51). On the other hand, single companies have the freedom to interpret the blueprint acting according to their project. The data also show that universities play a role in innovation, but the empirical research did not exhaustively analyze them.

Findings 3:

The findings for this section of the qualitative research are based on points 2, 3, 5, and 6 of the analysis. Point 2 (p.110 Appendix B) describes the general features of the industry, stating that the government is encouraging private production. Therefore, making the private interested in market activity and the public interested in state activities. Point 3 (p.111 Appendix B) shows how the government acts differently according to the single public agency. Therefore, NASA will develop its project, while the Defense will develop theirs. There could be overlaps and collaboration between government agencies in a real-world scenario. The results of point 5 (p.111 Appendix B) discuss the findings concerning strategy. What is relevant to report here is the hybrid role universities have in R&D, not only for scientific and knowledge purposes but also for market application. Point 6 (p.112 Appendix B) refers to the findings regarding the importance of epistemic communities inside the U.S. Space ecosystem. New companies do not come from anywhere; people already inside the space community start them. Relating to the sector organization, the relevance is that there is an influence on the location of companies and the internal organization. Epistemic communities lead to the creation of clusters due to the presence of knowledge, know-how, or infrastructure. Thus, epistemic communities shape the ecosystem's organizational aspects by influencing the industry's geographical location.

Discussion:

All three findings agree on the more general view that the sector is transitioning to a commercial approach. This process is allowed by the structure of its organization. Findings 1 explain the reason behind the change of approach, showing that the general explanation is that an organizational structure that allows freedom to the private is understood to have more innovative capacities.

Findings 2 build-ups from findings 1. They show the role of government institutions and agencies as an orchestrator in the ecosystem that, by financing and directing the private, stimulates innovation. Findings 2 also show the organization's geography and identify clusters in which the industry is established. Interesting to notice is that these clusters are composed of both public and private actors. Findings 2 also presents universities but needs to define them. Findings 3 build-ups from the previous two agree with the commercial trajectory the sector is taking.

Further, it defines the role of the public agency. It shows that each agency has its function and independence from the others. However, in the real world it is plausible that there is collaboration. Findings 3 define the university's role better by giving a hybrid role: both for research and market activities. Finding 3 agrees with finding 2 about the importance of epistemic communities. If findings 2 empirically showed the geographical location of the cluster, findings 3 qualitatively argued for it by emphasizing the role that knowledge, know-how, and infrastructures have in the organizational and geographical aspects of the sector. The three results do not contradict each other. As shown, there is confirmation in some cases, while in others, previous findings deduce new ones. This process is due to the nature of the research, in which there is ongoing development.

Answer:

Currently, there is a transition occurring in the sector that is leading to its commercialization of it. The organizational structure drives the sector's transition, affecting the innovation process. Thus, suggesting that innovation is developing for market application or to allow this form of application. Therefore, the organizational structure of the ecosystem is designed toward this goal. The results confirm this statement.

Sub-question 5: How does the funding system in the U.S. Space ecosystem influence the innovation process?

Findings 1:

The starting section of the thesis introduced the issue of the relationship between innovation and finance (p.13). Chapter 2 argued that innovation is generally seen negatively by the finance sector and, more generally, by those economic entities seeking an investment. The reason is due to the high degree of uncertainty that innovation has in it. The section "economic values of the space sector" (p.24) reported the potential capacity for growth that the sector has in economic terms. Nevertheless, even if that section is full of big numbers coming from several research and economic institutes, research material on funding from the finance sector still needs to be founded in the literature review.

Further, the OECD 2019 report writes that recent space companies are privately founded but not publicly traded (p.24). These elements suggest a low presence in the sector of financial institutions such as banks or stock companies. Given this, the conclusion confirms the opening statement about the negative relationship between the finance sector and innovation due to the high degree of uncertainty given by explorative economic activities. With the low presence of the finance sector, the research material suggests that the sector's funding belongs to public funds. The section "the space sector: a business ecosystem approach" (p.33) reported the example of SpaceX. The case shows that SpaceX made various contracts with NASA; without that money, it is plausible to say that it would have been difficult for SpaceX to develop. Other findings in the material suggest that substantial capital to the sector comes directly from the prominent entrepreneurs who, thanks to their funding capacities, could overcome the sector's costs. The above suggests that most of the funding is given by the government, making it the primary customer of the sector (p.33-35). Private findings play a role in the cost of access to the industry, yet once in, the suggestion is that most funding will come from the public area thanks to grants and space programs (p.36). Relating this to the innovation process, the low presence of the finance sector and the obligation to respect the duties towards the investors is positive for innovation. The positive views for innovations are because the finance sector has a negative relation to innovation, blocking the process due to the high degree of uncertainty that makes the return of investment riskier (p.21). It is plausible to say that the space sector has a high risk of investment, and it is plausible to say that part of it comes from the high degree of innovation needed for the technical development of the sector. The research material suggests that the government, through its foundlings, takes charge of the high-risk. The take of responsibility is an essential element, suggesting that most of the money that finances the innovation process in the sector comes from the government, but the private workforce makes it. Private fundings have a certain degree of importance. However, the sources suggest that private funds are used to overcome the cost of entry into the sector instead of financing the innovation process.

Findings 2:

Chapter 3 (p.22) discusses the relationship between finance and innovation. The relation is central to the thesis. Chapter 2 (p.13) suggests that the finance sector has difficulties financing innovation activity due to the high uncertainty that innovation has intrinsically inside it. Following this, the expectations are that most companies were privately owned or financed by joint ventures and capital funds. The presence of financial institutions, banks, and the stock market was not excluded completely, yet it was expected to be a minority and related to the mega-entrepreneurial companies. The data confirmed the expectation, given that the most common type of ownership is private (p. 96-107 Appendix A). This conclusion implicitly suggests the findings of the quantitative analysis (point 2 p.48), stating the low presence of financial institutions in the space industry (p.48). Looking at the number of employees for each company, it is possible to notice that most companies have less than 500 employees, suggesting that they are big-entrepreneurial companies but not mega-entrepreneurial (p.104 Appendix A). This element also suggests what was described in the literature review section, arguing that companies more circumscribed and privately owned have less obligation and concern towards investors and can dedicate themselves to more explorative activities bootstrapping innovation. According to this description, more prominent companies acquire the positive outcomes of the explorative activities, transferring them through commercialization to the market. Following the financial analysis, the space sector follows this internal process, so a positive relationship between finance and innovation in the ecosystem can be drawn. In general, from the quantitative analysis, what emerges, is a vertical finance structure. Companies are privately owned, and NASA is the orchestrator of the ecosystems and creates programs inside the ecosystem (p.95 Appendix A). Companies apply to these programs to get grants and contracts with NASA. Following, the type of finance is vertical, in the sense that NASA creates spillovers of its budget to finance investment and develop the ecosystem.

Findings 3:

The qualitative research confirms the results of the other two findings. The presence of banks and the finance sector is low (p.111 Appendix B). This is because banks are risk-averse (p.111 Appendix B). The high degree of uncertainty given by the development stage of the sector and the high degree of technology needed makes the level of risk high, thus, lowering the presence of banks as investors. The research shows that banks participate in the sector as insurance, facilitated by government policy (p.110 Appendix B). The qualitative research suggests that banks could participate in the sector as investors. If this were the case, it is more plausible to imagine banks taking part with mega-entrepreneurial companies compared to smaller ones. Less risk of investment gives the reason.

Discussion:

The three findings share the same broad view that most of the sector's funding comes from the public sector. However, to overcome the entry cost of the sector, there is the use of private capital. All three results also confirm the low presence of banks and the financial sector in general.

The low presence is explained by the high degree of risk and uncertainty that the U.S. space sector has with investment. Findings 3 have shown that there is a presence of banks in the ecosystem as having an insurance role. This finding is neither confirmed nor rejected by the other two. Findings 2 have zoomed inside the dimension of the companies in terms of employees. The choice in focusing on the dimension was to confirm the hypothesis that privately owned small companies are less restricted in innovative exploration activities due to the less obligation towards investors. Findings 1 and 3 do not explicitly confirm the findings, but looking generally, the descriptive narrative of the sector suggests that the confirmation is plausible.

Answer:

Innovation is an activity with a high degree of uncertainty and risk. The direction of the funding actively influences the innovation process. In general, the low presence of banks and the finance sector is positive for innovation. A high presence of the finance sector in the space ecosystem would lower the innovation process. The absence instead increases the freedom for explorative activities.

Further, a meaningful answer is that innovation levels are more present in smaller companies with less obligation compared to the mega-entrepreneurial companies. This answer fits the innovation process because the findings argue that once a small company develops a new technology or practice, it is absorbed in a second moment by more prominent companies to be commercialized. This acquisition process between small and big companies is an active part of making innovation in the U.S. space sector.

Question 6: What insight do the three methodologies used in the research provide on the innovation processes inside the US Space Sector?

The above sub-questions are all related to the main research question of this thesis. The research aims to explore the innovation process inside the U.S. Space sector by enquiring how the interaction between the actors of the industry influences innovation. The sub-questions findings are unified to construct a coherent explanation of the innovation process. From this coherent explanation, the main question answer follows. These findings are not related to a sub-question but show insights about innovation during the three research methodologies. Thus, the findings of this section will then be integrated with the above conclusions leading to answering the thesis research question.

Findings 1:

Chapter 3 understands space as a grand societal challenge (p.29). This understanding means that the sector has a high amount of complexity, and to translate complexity into action; the literature review shows that the sector is following a mission-oriented approach (p.22). The approach highly influences innovation by making the government develop policies to develop specific technologies. Innovation then emerges as a collaboration between public and private organizations, which is possible through three points: (i) create links between space and non-space systems; (ii) coordinate long-term infrastructure; (iii) catalyze and manage space innovation systems (p.28-29). Therefore, the literature review shows that the dichotomy of government and private creates innovation in the U.S. space sector.

Findings 2:

For defining innovation in the framework, the definition given by the European Commission Green Paper on Innovation (1995) was used (p.18). According to this definition, innovation does not only stand on the technical and technological side of an economic ecosystem but also in the management, organization of work, distribution process, increasing of products, and change in the skills needed for the workforce. Following this view, the data collected shows that today innovation is an ongoing process inside the sector (p.107 Appendix A). The process is not only in the technical and scientific components of the ecosystem but even more in the development of all those elements that create the technical outcomes and scientific knowledge needed for development. The entrepreneurial shift in the sector as the most diffuse economic activity supports the view of innovation as an ongoing practice in the sector (p.96-107 Appendix A). Further, the framework has suggested the concept of emergent innovation understood as knowledge at work (Peschl & Fundneider, 2008). The authors offer a six-point framework on how to predict emergent innovation basing it on knowledge (p.19). Applying these six points to all the ecosystems is seen as the framework at work. The first point of the framework is to acquire knowledge. This process was made during the start of the space sector, in the "old space" period, when NASA and the oldest companies were starting the sector. Today, by observing the development of the sector through the space programs proposed by NASA as well as the increasing number of companies in the last two decades, it can be argued that the sector is at point six of the framework (generated knowledge embodied in the ecosystem).

The financing of the sector is another element that suggests a strong presence of innovation in the space industry. The empirical data show a low presence of banks; the most significant investor is NASA (i.e., the U.S. government) (p.102 Appendix A). Further, as reported in the summary of conclusion 5 (p.107 Appendix A), most companies are privately owned, meaning they have a relatively low presence in the stock market. The low presence is explained by following Mazzucato's idea, in which the scholar suggests that the high uncertainty of innovation make banks and big finance organization not interested in the investment of the high degree of losing profits (p. 15). The last point of conclusion regards the flow that innovation follows inside the ecosystem. The framework uses the work of Kollar (2015), which goes against the classical view of innovation as a bottom-up process, stating that innovation is multi-directional (p.20). The quantitative study argues for the confirmation of this perspective. The description it offers makes innovation a top-down process (as NASA plays a role), bottom-up, that are directly the companies that stimulate innovation, and horizontal trajectory because there is a transfer of knowledge and practice. The transfer of knowledge and practices play a role in the creation of an epistemic community in the space sector.

Findings 3:

The findings of the qualitative analysis highlight four points concerning innovation. The first is related to funding. Private companies make innovation activities financed by government money (p. 110 Appendix B).

The second point refers to a distinction between private companies. Big companies absorb small companies that usually go bankrupt (p.114 Appendix B). Thus, there is a knowledge transfer in the process that increases innovation. Third, it is not easy to measure the return on investment that innovation makes (p.114 Appendix B). Fourth, there is a shift in the knowledge trajectory of innovation (p.114 Appendix B). Commercialization pushes companies to develop in R&D. In the first stage, R&D activities are developed by using government money for government purposes; however, in this process, companies acquire knowledge. In the second stage, companies gain independence from the government by selling their products to private customers thanks to the knowledge acquired during the process of development started with government funds.

Discussion:

The three findings agree with the general view that innovation emerges from government and private cooperation. Two of the three points of the mission-oriented approach described by findings 1 are confirmed by the other two findings. The interaction of knowledge creation creates linkages between space and non-space and market customers, both proved by the findings. The presence of government agencies like NASA creates guidelines and long-term projects for the long-term.

This statement was proved in other results as well. Point three, which refers to the management of the space system instead, was not confirmed by the other two results. Findings 2 and 3 confirm that small companies contribute to the innovation process due to their high degree of freedom. And then, their knowledge is transferred when absorbed by more prominent companies. The presence of government funding is essential because it allows the application of the concept of the "entrepreneurial state" concerning the domain of space to the U.S. government as presented in the theoretical framework.

Answer:

The conclusion that emerges from these findings is that the state has an active role in the innovation process in the U.S. space sector because it is the first one to believe in space development. Without state participation, the U.S. space industry would not be developed to the point it is today.

Policy recommendation

The conclusions of the thesis have shown how the partnership between private companies and government institutions shapes and creates the innovation processes inside the US space ecosystem. These conclusions were made by tracking and inquiring about the different stakeholders present in the industry. From these results, the thesis pushes the research further by suggesting recommendations for future development on a policy level. This is made in two ways: the first, on a general level, by suggesting some implementation to the space sector. The second zooms in and offers suggestions concerning the innovation processes.

General policy recommendation

When looking at space, there is the sensation that the industry is unrelated to the social context around it. This social detachment is even more true when the rhetorics from the media are analyzed, and the impression is that the space industry is becoming a playground for prominent tech billionaires instead of developing social value, human knowledge, and, more in general, humankind flourishing. Therefore, the suggestion, much more broad and speculative, is that space should be more embedded in the social context in which its infrastructure belongs. Further, today's societies are facing complex and critical challenges, the space sector and its technology can play an important role in facing these challenges, but for this, its development should be towards the needs of the most instead of the few. When considering the macro areas of society, space is a sector that can have positive disruptive consequences. Several of these benefits were described during the thesis, but today this type of social development is not taking place. It seems that space is developing on the micro level (especially with the last development of space tourism), which supports the entertainment of a small group of people. This outcome is ethically debatable, thus raising the question of society's actual needs towards this type of space industry and, even more, what this suggests for tomorrow's society.

Innovation policy recommendation

The thesis has shown the central role that the state has in the innovation process. This role was framed under the concept that Mazzucato created of an "entrepreneurial state." Therefore, the research shows that if it is desirable to have an economic system that stimulates technological innovation, it is essential to have an economy in which it is the state that drives the innovation processes and that it assumes the risk. This section argues that the entrepreneurial role of the state should be shared with the public with a more considerable emphasis. The public should know the importance of the state, even in a liberal economic system. This knowledge is important because a more informed public leads to better political decisions. The second recommendation is that technologies are never neutral, which is also valid for space technology. Therefore, a more extensive ethical consideration around the use and values that space technology should be more central in the institutional framework. This statement is true both for the user property rights that its application. The accessibility of space technology for society has become debatable. True is that several parts of society and private citizens use communication, navigation, and satellite infrastructure. Nevertheless, ordinary people cannot use other types of technology (such as the application of technology for space tourism) even though the development was made possible through public funding. Therefore, policies that focus on broader accessibility of space technologies and protect public money from being wasted for projects that are not shared in society should be implemented.

Reflections on the research

This section of the thesis critically reflects on the limitation of the work carried out and suggests possible improvements.

The thesis has three significant limitations: the starting phases of the research, the concepts used, and the processing of the methods used during the research. The limitations of the methods are present in all three methodologies.

Starting phases:

The thesis started with ambitious goals, and these high expectations make it a weakness during development. Ambitious goals are generally positive, but they could lead to a need for a more precise focus by driving the thinking process on a too-general level.

From this limitation, a possible improvement would have been to narrow down the scope of the research since the preliminary phases of development, making the aim of the research more explicit. In this sense, the research question plays a central role, and for this research, one of the biggest challenges was developing an appropriate one.

Use of concepts:

The thesis uses several concepts taken from the academic and policy environment literature. It uses market ideas derived from Schumpeter's theory, economic concepts developed by Mazzucato and colleagues, and concepts from policy documents such as the Green document of Innovation (1995) of the European Union, and it develops some arguments from futurist studies when describing the space industry. Applying these concepts is relevant to the topic and aim of the thesis. However, there is no discussion of the background assumptions; thus, if on the level that the thesis uses them, their use is justified, if the assumptions are questioned, incoherence could emerge, leading to potential limitations.

It follows that to improve the analytical strength of the research, an explicit presentation of the underlined assumptions that each concept carries about the context of use is needed.

Method process:

a) literature review

The research uses three different types of data and sources from which it draws conclusions. Each type of data has its limitations. The first consisted of a literature and document review with material from academia, government institutions, private research centers, and grey literature from the media. The thesis extensively reviewed the literature by focusing on the essential material for the research aim. However, besides the effort during the research process, it cannot be excluded that relevant literature for the research topic was left out. Further, the research phase was carried out from the end of 2020 through the spring of 2021. It is possible that from that period to the one of concluding the thesis, new works with valuable findings were published, and if this is the case, this thesis does not take the latest work into account.

b) quantitative analysis

For the quantitative study and the related analysis, data were collected by all US space companies encountered during the research process from the various text used and by searching with Google. Several companies were identified and analyzed; however, it is plausible in the empirical analysis that companies were not considered due to the lack of research or because they were connected to the space industry in indirect and less visible ways. Thus, this could lead the research toward an inductive risk in its conclusion. Possible inductive risk means that generalization could occur by drawing concluding statements on the sector using under-representative data. To avoid this, more in-depth research for relevant stakeholders in government databases could decrease the possibility of misrepresentations and unsatisfactory results.

c) Interviews

The last limitation of the thesis is in the qualitative analysis section. The method used for the qualitative analysis is semi-structured interviews. The limitation in this section is the number of interviews carried out.

Time and effort were invested in searching for relevant interview participants. Several US space sector experts that work with different stakeholders and social groups were contacted for an interview session. Unfortunately, most of them did not reply to my invites, and in the end, only one interview was conducted. As the thesis shows, the interview was of great help for the thesis, and it helped to clear some points that the other two methodologies did not answer. However, this low number of interviews must be considered an essential limitation of the thesis because no second opinions or views are presented, which makes this part of the thesis subject to possible biases. Therefore an improvement is to increase the number of interviews. The candidates should still be sector experts, but it would be good if these people would represent the different stakeholders in the industry.

Conclusion

The thesis discusses the innovation process inside the US space sector. The reason for choosing the space industry is that it is an interesting case to analyze innovation processes. The motivation behind this is given by the relatively small dimension of the sector, making it easier to trace all the relevant actors; nevertheless, space is a sector that shows enormous growth potential. Further, this sector requires high technological levels, meaning high innovation levels. Therefore, innovation is linked to uncertainties, and as it was shown, banks are generally risk-averse, making space a sector with a low presence of financial institutions.

The thesis does not discuss innovation on a technical, engineering, and material level but by inquiring about all the different relations set between the sector actors. The concepts used are tools that frame the sector as a complex system with interdependency between actors. Because of this, the thesis applies the business ecosystem concept to the sector. To better answer the research question, five sub-questions were made. Each sub-question inquires about a specific element that has an active role in the innovation process; these elements are: motivation, strategy, competition, organization, and funding. Most of these elements share the difficulty of measuring them in quantitative terms. Therefore, the thesis uses three different methodologies.

The first was a literature review and analysis. This type of analysis shows the state of the art and how different parts of society perceive and describe the sector, using several sources of different types (academic, policy, grey literature, and media).

The second methodology was a quantitative study based on empirical methods of analysis. At first, it was made an identification of the organizations that are part of the sector. Then, the research zooms in by looking at several parameters and linking each parameter to the organizations. This was then used to create an overall analysis. The empirical section offers a detailed description of the space sector; because of this, the last part of this methodology section interprets the description given by the analysis. The interpretation was needed to connect the empirical findings to the five inquired elements.

The third methodology of the thesis consists of qualitative methods that use semi-structured interviews. This section aimed to gain insight and knowledge of the sector by using the opinion and the day-to-day knowledge and views of experts in the sector. The section is of essential importance for the thesis because aspects not considered in the previous two analyses emerged.

The findings from the three different analyses were then triangulated to find confirmation or rejection between each finding leading to results.

Historically dividing the sector into two categories, the "old" and "new" space was the first significant result. The thesis focused on the "new" space, meaning a development towards commercialization is the most considerable interest of the sector. The results of the big picture of the "new" space show that the US Space sector, at first view, is immersed in a bigger narrative that can be traced back to what is generally called American culture. This view leads to embedded rhetoric that promotes the view of the sector in which the private companies' creativity and dynamic activities are drawing the industry's development. The thesis shows this is not the case, especially regarding the innovation process and trajectories that the sector follows; however, the narrative is a crucial component of the motivation that pushes the ecosystem. As a result, a complex relationship between the private sector and the government with its related institutions emerged. The ongoing partnership on an ecosystem level between private and public stakeholders is what stimulates the innovation process. Tracking the policy history of the US space sector, it was possible to see that over the years, there has been a tendency to go towards the commercialization of space, opening the industry to private companies. The fact that most companies operating in the "new" space were founded in the last twenty years supports the claim. The reason for the opening to private participation is that private companies are usually more dynamic in technology development because of the less bureaucracy compared to government organizations. However, to achieve this transition, the state first has to create the conditions for the private to enter the industry. Therefore, the US government adopted a strategy of market failure that it conceptualized by Mazzucato as an "entrepreneurial state." The concept implies that the state takes the risk of investment. To do this, it uses its systems and apparatus by creating the infrastructure both from the material and knowledge level to support private companies' entry. The thesis shows that this was made possible by creating and using knowledge and R&D centers as universities, NASA facilities, and research centers. The geographical clusters of knowledge and industrial production emerged as a consequence of the strategy, leading to the creation of epistemic communities inside the sector. The epistemic communities have an important role as part of the motivation component and in developing the know-how and practices of the industry. This type of organization of the sector resulted in essential, allowing private companies to enter the sector. The type of organization the space ecosystem follows influences the development and operational strategies. The thesis shows that besides the rhetoric and framing of the news shared on a public level, a different story emerges when looking at the strategy. It was proven that government institutions such as NASA, the Science Foundation, and the Department of Defense, represented by DARPA, create space programs through which they stipulate contracts with private companies to develop the technology required by the program.

Therefore, the government is the first client and investor in the industry. The reason is that being the first client can stimulate the transition towards a commercial approach to space.

The thesis reveals the mechanisms that pass through the partnership between the private and public parts of the sector concerning the commercial transition and the related innovation processes that take place. The research shows that the government provides the means to private companies to develop and manufacture their technology. At the start of this process, the private company depends on the state. However, during the developing phases and by realizing government projects, the companies acquired knowledge and skills, developed technological infrastructure, and earned revenues. All these factors make it possible for the companies to acquire independence from the government. Furthermore, with this autonomy, they commercialize their products by adding them to the market, creating selling and buying processes between private companies.

This type of innovation trajectory is the main result that the thesis proves, highlighting that innovation mechanisms could only occur with the state's participation as the leading force. Therefore, this research takes distance from the liberal view of economics that understands that to have a productive system that stimulates innovation activities deregulation framework with a low presence of public participation should be adopted. The thesis locates itself on the new revisitation of the innovation process that argued in favor of public participation, and the most desirable system that stimulates innovation processes is one in which it is the state the first entrepreneur of the economy.

Table and figures

All the tables in this research are made by the author and resulted from analyzing the empirical data chapter 5 uses. In the research, two figures are present as well. The first is a graphic representation of the conceptual model. The second describes the triangulation process that the research uses in the result chapter. Both figures are made by the author using the software present at lucichart.com.

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Appendix A: Quantitative analysis

In the analysis, most organizations have overlaps in several parameters. For this reason the analysis uses the point system described in the operationalization chapter. When the system is used it will be explicitly said, when is not mentioned, it means it was not applied. The aim of this methodology is to give a better description of the ecosystem.

Following, the analysis of the thirteen parameters is made:

Sub-sector analysis:

With sub-sector, the text refers to five big sub-sector of the space one. The description of each sector is the following:

- <u>Hardcore manufacture producer:</u> hardcore manufacture is meant companies that produce directly the technology, infrastructure, components, and material that will be part of the space sector. As it was expected on the 49 companies identified, 29 are involved in the production of hardcore components and technology assembly. These companies also provide technologies, infrastructure, and vehicles (such as rockets, spacecraft, and satellites) to others companies in the sector. Furthermore, the manufacturing activity is the most widespread productive activity that the companies of the sector do.
- <u>Satellite communication:</u> it refers to companies that are involved in the service related to satellite activities. These activities can be satellite communication for several uses (military, maritime, aviation, scientific expedition as example to the poles), but also it is referred to TV and radios networks, internet and cloud service. As expected, satellite communication is one of the most widespread activities in the sector. It was identified as 9 companies directly related to this sub-sector. This was expected also for the volume of revenues involved and as one of the first activities that took place in the commercialization of space.
- <u>Data:</u> data is related to satellite activity and stratospheric balloons. Data is meant collection and analysis of raw earth and atmospheric data for forecast modeling and observation. With data, it is referred also to GPS navigation systems. Data is a growing market, that is directed to commercialization to private, government institutions, academia, and scientific groups as primary buyers. It where identified 8 companies that are involved in the market, and most of the companies are also part of the satellite communication market, because of the infrastructure and satellite constellation already present. Data are important for weather forecast, earth management, urbanization and pollution control, military and security surveillance, government prevention for natural disasters, maritime and aviation route

creation, GIS systems as well as other scientific purposes. For all these activities, the commercialization of data is becoming a more important activity.

- Launch service: with launch activities is meant all those activities that enable physical access to space. This can be done through direct rockets launch or organization and management of the mission. It was identified 14 companies that take part in this market. Most companies also produce their launch vehicles, only 3 out of 14 do not provide launch vehicles. One is specialized in the management of the launch mission, while the other two, the launch vehicles are provided by partnership companies or subsidiaries.
- Tourism: tourism is meant the activity of commercialization of personal space flights. As it was seen by the literature and reports, space tourism is an activity that has increased in the last few years. Six companies were identified that take part in the market, several modalities of operation were also identified (space planes, rockets, stratospheric balloons). Some companies (such as Virgin Galactic and BlueOrigin) already are operating tourism space flights, while others would be active in the next years (as Space Perspective, and World View Enterprise).
- Testing service: With testing, service is meant the activity of testing developing technologies such as flight and propulsion systems. This was a market not taken into consideration at the beginning, and only two companies were identified. The reason for only two companies present could be because most companies test their technologies by themselves. Yet, it is interesting to notice the increase of space companies, also of small dimension, and this could raise the need of certain service increasing the market. Following the above it is obtained the following point rank for each sub-sector (table 1):

The data reflect the starting expectation. Direct manufacturing of products, technologies, and infrastructure, combined with the accessibility of space are the two major sub-sector and economic activities that the sector provides. Following, data and communication services are important activity, and also it can be noticed that the tourism sector is growing. Regarding the testing service, only two companies operate in the sector according to the data collected. This can be a sector for further inquiry considering the growing numbers of small businesses involved and the need to test their technologies.

Table 1 Point rank for sub-sectors

Sub-sector	Number of companies
Hardcore manufacture producer	29
Satellite communication	9
Data	8
Launch service	14
Tourism	6
Testing service	2

Specialization:

Each space organization acts in one or more sub-sector, and for each sub-sector companies have their specialization depending on what role, what projects, what relationship, what motivation and goal, they have in the market. Table 2 describes the types of specialization and the numbers of companies for each category.

Table 3 category of specialization

Category specialization	Number of companies
Space accessibility	117
Space flight technology	19
Space human fight	27
Lunar development context	9
Satellite radio and broadcast	3
Data, Earth observation, mapping and navigation	22
Science and space exploration	21
Testing technology	3
Security	1
Energy and fuels	1

These categories differ from the sub-sector described in the previous part because this regard more operationalization aspects and production processes in which the company activities fit in, instead of market-product perspective like the sub-sector. To understand better, 10 categories are realized from the above specialization. Each specialization is grouped under an activity. The numbers refer to how many organizations are part of the category. A company can be part of more, but each category is counted once. By this analysis, table 3 is obtained with the related division.

From the above (table 2-3) it’s obtain the following description:

Looking at the collected data in the single specialization overlaps appear as expected. As it can be noticed that many companies develop rockets engine and propulsion systems, most of those companies also develop other rockets components, space crafts, and instruments, as well they offer launch services for space access. Companies that offer satellite service usually do not focus on the manufacturing of the satellite itself but on the communication and data service to offer to their clients. In general, it can be noticed that most of the companies' specialization focuses on the accessibility of space as with launch vehicles and services for satellite or space crafts. Another important volume of the organization focuses on the needs of humans regarding space, as a life support system, space modules (for intergovernmental and private projects) as well as direct access of space for humans. For humans space flights two types of specialization were made, one for “professional” astronauts and space agencies, and a second one for private and tourism. It is possible to notice that there are six companies for each category, and some (as BlueOrigin) operate in both markets. What is possible to notice, is the different types of space flight for the categories, while for professional astronauts rocket vehicles are preferred, for private flights space plans or stratospheric balloons are chosen. Another important field of specialization is the lunar development context. As expected the Artemis program (next section for further details) represent a big opportunity for many companies, and so several are the companies in the ecosystems that are developing for the lunar context in all its aspects: from landers, communication service, logistic, vehicle and so on. Another important specialization of the space sector is what concerns satellites mapping, observation, and data. Several sectors outside space are increasing the demand for data from earth observation. From the weather forecast, land management, pollution control, urbanization, as well maritime and aviation traffic. The request of this data and its analysis opened to new specialization, in the service sector as well in the manufacturing one with the development of small and nanosatellites. This also increased the need for launch service, developing further the space ecosystem. Data and observation companies are less compared to manufacturing technology, rockets development, or satellites communication, yet according to the data collected, they represent an important specialization that could increase in the next years. According to the data also scientific activities for space exploration are an important specialization for organizations. This can be noted taking in consideration rovers development, space observation, astronauts flight systems, and space station infrastructure. What this data makes unclear are the following two main ones aspects: the first is the category of space and security, identifying just one company Other parameters instead demonstrate the presence of military agencies inside the ecosystem. The reason of this ambivalence is unclear. The second, is the energy systems represented by the fuel needed for the rocket and launch vehicle. Just one company was tracked under this voice, but for the number of organizations involved in the ecosystems, it was aspected to find more.

Table 2 specialization sector in the US Space Ecosystem

Specialization	Number of companies	Specialization	Numbers of companies	Specialization	Numbers of companies
Technological and hardcore producer	22	Space crafts and components	6	Lunar logistic company	2
Logistic	12	Sub-orbital and orbital rockets	11	Launch service management	6
Space system manufacturing	7	Rockets engines and propulsion systems	12	Robotic lunar landers	6
Launch service for satellites	13	Small launch vehicle	7	Space and security	1
Space crafts instruments	11	Communication lunar service	1	Commercial space modules	1
Earth observation	5	Service provider	3	Energy systems	1
Communication satellite	7	Service in clouding delivery to ISS of cube sats	1	Personal space flights	6
Life support systems	8	Earth remote sensing	1	Rovers and robotics	7
Space crafts transpiration	2	Radio occultation	2	Space station manufacturing (for ISS or intergovernmental projects)	4
Launch service	12	Weather data	3	Mission design and management	3
Crew spacecraft (not for private)	6	Space infrastructure	2	Design	2
Satellite television and radio broadcast	3	Stratospheric ballons	4	Vehicle production (flying and not)	10
Mobiel satellite telephone	3	Satellite data and analysis	9	Space observation	4
Software development	2	Launch vehicles	1		
Service technological industrial company	1	Manufacturing technologies (3D printer)	6		
GPS and mapping navigation service	5	Launch service flights	3		
Consumer equipment	1	Flight service test	6		

Economic activities

This section of the data collected shows the main products that each company develops. These products reflect what the data said about the space sub-sector and specialization that each organization has. This was a not easy analysis, the reason for this is that in the ecosystem there are presently several different types of companies of different types and dimensions. For some companies was easy to identify and classify their products because their focus was on just one or two, while for major companies their range of activity is much wider, making it difficult to track all their productive activities. Because of the variety of products, two categories are made: hard products, referring to hardcore technology and manufacturing, and soft products, referring to soft technologies like software and related service (on top of all satellite communications and applications). Table 4 shows the results of the analysis applying the point system.

Table 4 type of products of the space ecosystem

Category	Number of organization
Hard products	35
Soft products	25

Program involved

As expected by the literature NASA plays the role of the orchestra in the ecosystem. NASA creates programs and guidelines with the US government for the development of the space sector, having a leading role in the ecosystem. NASA in 2020 had a budget of 22.6 billion dollars, and most of that funding was turned to private companies under programs for space development. This section collects data about the involvement inside NASA programs for each company.

Important conclusions can be drawn by this data analysis: for instance in which direction is NASA and the US government pushing space development, which scenario can open, how the ecosystem can evolve, but also about internal relations of the ecosystem, the role that institutions have as well motivation and strategies at hand. From the data collected it is obtained table 5. The analysis concludes that NASA programs have a relevant role and involve a relevant amount of organizations inside the ecosystem. Indeed, the table (5) shows that not specified relations have also an important part with 25 organizations. This number should be further questioned. On the other side, NASA programs are involved with a total of 34 companies. On top of this Artemis is the leading program.

Table 5 NASA space programs

Name NASA program	Number of companies
(a) Not specified	25
(b) Artemis	18
(c) Radar SAT-2	1
(d) Commercial Crew and Cargo Program (it has COST + CCP)	5
(e) Commercial orbital transportation service (COST)	2
(f) Commercial Crew Program (CCP)	3
(g) Next Space Technologies Exploration Partnership (NextStep)	1
(h) NASA CubeSat Provider for Mars Mission	1
(i) National Oceanographic Partnership Program	1
(j) Commercial Lunar Payload	3
(k) DART	1
(l) IXPE	1
(m) ElaNa	1
(n) Flight Opportunities Program	1

This is quite a surprising result and important insight into the future direction and development of the ecosystem can be suggested. A surprising result was also to see that only 5 organizations are involved in the Commercial Crew and Cargo Program, and this is data that needs further inquiry. Other minor programs reported can tell compulsory insight into the ecosystem. Some programs are related to the scientific aspect of space possibilities (G, J, M), others (L) are related to the monitoring of potential asteroids danger, and others (N, O) give insights into the accessibility of space. In general, this data can give us more information about the relations with institutions, the strategy and competition involved, the motivation of the ecosystem together with the financial aspects.

Ownership

The data collected with this parameter has aim to give insight into the financial aspect of the ecosystem together with the strategy and motivation relations.

Four different types of ownership were found, table 6 shows numbers of companies for each type of ownership.

According to the data collected, private ownership is the most common, also the public share form is a spread form of ownership. On the other part joint venture as well direct ownership from other organizations is not common type of ownership inside the ecosystem. The reason for this can be multiple and further inquiry must be done.

Table 6 types of ownership in the space sector

Types of ownership	Number of companies
Private ownership	26
Public share	18
Joint venture	3
Owned by other companies	1

Alliance and partnership

As already stated the importance of this data is to describe explicit relations of collaboration between organizations. Several were the alliance and partnership collected, compared to 22 organizations in which there was no specification. Most partnerships are inside the ecosystem, but some are related to companies outside the US borders as well as companies that are part of other economic sectors. Putting together the data table 7 gives the following description.

Other companies do have partnerships and collaborations but between subsidiaries of the same corporation. For this reason, these companies were not taken into consideration in the table (7), because even if they collaborate as independent companies they are part of the same group. The following list refers to the companies under this description:

- Raytechnologies
- SiriusXm
- DishNetworks
- Redwire
- VirginGalactic

The data show that most of the partnerships involved between companies are inside the same sector, ecosystem, and state. An important number of partnerships also regard organizations that are part of the same sector but outside the US borders. This suggests the global aspect of the Space Sector. The result is not a surprising one, considering the global aspect of the contemporary economy and the increasing amount of trade and collaboration given by globalization. Not surprising is also the important partnership of companies that are in the same state but different sectors. This is as well an expected result given the complexity of the space sector and its internal needs regarding materials, research, technological development under multiple aspects. What is surprising, is that according to the data, most of these needs are satisfied by external companies from the sector arrive from US-based companies, and not by international partners, surprisingly results if compare to the international dialog of space companies.

An important data is the number of not specified partnerships, 22 in total. This data does not mean that the companies do not have a relationship, but that during the collection of data information about it was not found. Because of the important amount of companies under this category, further inquiry should be done to have a better understanding of the ecosystem from this specific section of the data.

Table 7 Companies partnership inside and outside the US Space Ecosystem

	Partnership regarding the Space Sector inside the US borders	Partnership regarding the Space Sector outside the US borders	Partnership outside the Space Sector but inside the US borders	Partnership outside the Space Sector and outside the US borders	Not specified
	Boeing and Lockheed Martin (jointly they form the United Launch Alliance)	International Launch Service and Khrunichev State Research (Russia)	SpaceX and Google	UP Aerospace and Reactive Technologies (UK)	
	Dynetics and Maxar Technologies	Nano Racks and Thales Alenia Space (Ita/Fra)	SpaceX and Microsoft		
	Dynetics and Astrobotic	UpAerospace and Cesaroni Technology Corporation (Canada)	Intuitive Machines and IBX		
	Iridium and Hosted Payload Alliance	SpaceFlight Industries and Thales Alenia Space (Ita/Fra)	Intuitive Machines and X-Energy		
	Axiom Space and SpaceX	Relativity Space and Mu Space Corp (Thailand)	VirginGalactic and Boom Technology		
	Axiom Space and Intuitive Machines	Relativity Space and Telesat (Canada)	VirginGalactic and Under Armour		
	Bigelow Aerospace and SpaceX		UpAerospace and Controlled Dynamics		
	Bigelow Aerospace and Boeing		UpAerospace and GoPro		
	Bigelow Aerospace and United Launch Alliance				
	Raytheon Technologies and Blue Canyon				
	BlueOrigin and United Launch Alliance				
	BlueOrigin and Boeing				
	Firefly Aerospace and SpaceX				
	Intuitive Machines and SpaceX				
	Nano Racks and SpaceX				
	Nano Rack and Boeing				
	Relativity Space and Lockheed Martin				
	Relativity Space and Iridium				
Total	22	6	8	1	22

Sector of interest

Table 8 gives a representation of the data collected concerning the sector of interest of the US space sector companies. From this, the following description is obtained.

The analysis of the data confirm the expectation. Self-commercial entrepreneurial activities are the category of major present, and this suggest a switch in the new space development.

The development of the "old space” sector was an independent activity. Most of it was driven by public and government fundings to be used for scientific purposes and economic activities of government interest. Table 8 suggest that in the “new space” there is the possibility for the development of cross-over economic activities between sectors. Space is seen as an entrepreneurial sector of interest. This, is explained by the increase possibility of accessibility. This is an important conclusion for tracking the co-evolution of the ecosystem and the strategy inside it. Important sector for space companies to operate and full the needs are also the scientific, government, communication, and security. From this data it is possible to state that these sectors see in space important possibilities of development. The last three sectors that result from the data (tourism, technology manufacturing, food, and agriculture) can be viewed as relatively new in the space possibility. This suggests that technological progress and the increase of space accessibility, are bringing space to enter into more sectors, raising the question of what will be the next one that space will enter.

Table 8 Sectors of interest of US Space companies

Sector of interest	Number of organizations
Scientific	17
Government	15
Communication	12
Tourism	7
Security	12
Technology and manufacturing	3
Food and Agriculture	2
Commercial/entrepreneurial	36

Relations with NASA:

As stated, NASA is understood as an orchestra of the ecosystem, creating founding programs and guidelines for the development of the space sector. This section aims to prove this statement, understanding clearly the role of NASA in the ecosystem. Furthermore, important insights into the relations that institutions and founding have inside the ecosystem can be given.

In this section, the data are divided into two voices: direct relations, and not specified. The first is referred to the situation in which the company is part of a NASA program or project, sells its service or products to NASA, or has received funding from NASA for financial projects. The second one refers to the not finding of data related to the category, but relations could still be in place. The data exclude one another, so an organization cannot be inside both voices. Table 9 describes the situation.

According to the data, NASA has direct relations with an import number of companies, as well an important number does not have specified relations. Looking at the data, it is possible to notice that most companies that do not have specified relations with NASA are part of the satellite communication sub-sector and more in the specific on the providing of communication networks and commercialization of data. Thus it can be understood the no-relations with NASA. There is no reason for the companies and NASA to relate to each other, if the companies are interested in the commercialization of space service, not in the development of the space infrastructure or technology. The relations in this sense could be an indirect one because these companies rely on the infrastructure (as launch service and satellites) that other companies have developed under NASA or with NASA funding.

Table 9 types of relations with NASA

Type of relations	Number of organizations
Direct relations	32
Not specified	17

Relations with institutions:

As the complexity of the Space sector, but also the relevance that space has under several governments perspectives (internal security, scientific, military, transportation, etc..), this section describes other institutions that take part in the ecosystem outside NASA. This is important because it adds other orchestrators in the sector giving further insight into the internal relations regarding the strategy, motivation, institutions, competition, finance. To have a more accurate description focusing also on the international aspect, in the data collected are taken into consideration not only the US institutions but also international ones. In this category, companies can have overlaps, and for this reason, the point system is adopted. Applying the analysis table 11 gives the following. Looking at table 11, the US Department of Defense plays an important role. The US Department of Defense is divided into several difference groups, the division is the one that table 10 describes:

Table 10 division in groups US Department of Defense

US Department of Defense	**Total number 12**		
US Air Force	3	US Space Force	1
DARPA	4	SOCOM	1
US Army	1		
US Navy	1		

As expected, the data collected prove that after NASA the most important institution involved in the US space ecosystem is the US Department of Defense. The reason for this can be related to the strategic role that space has in security and surveillance, as well as the high-tech development that the sector has embedded inside it. The military's interest in space is not only related to the US government, but also other States have interest, and US companies are helping them in their development, examples are Australia, Europe, and Saudi Arabia. What it is interesting to question following the interest of military institutions to space is that the UN Space Agreement clearly states the no military use of space. More under this perspective has to be questioned. Other institutions outside the military also involve space companies, but the most involve one or two companies, regarding activities like earth observation and data collection for management activities and navigation systems. The two most interesting points that this data gives are the importance of the military institutions inside the sector, and a large number of international agencies, suggesting that US companies play a key role also in an International level.

Looking at institution is important to mention the Google Lunar X Award. Even if google is not an institution, but with this program it takes the role as institution. The award was mentioned to make accessible Moon, and by creating a valuable project Google was offering grants. The project did not have winners, and for this reason it was not taken in consideration by tracking the company that took part of it, but it is worth to be mention because it could represent a change in the strategy of the ecosystem.

Table 11 Presence of institutions in the US Space Sector

U.S. Institution agencies	Numbers of organization	International institution agencies	Number of organization	Not specified
NASA	32	Saudi Arabia Military Department	1	12
U.S. Government Emergency Department	1	Japan	1	
U.S. Government Research Department	1	United Kingdom	3	
FAA	1	Singapore	1	
NOAA	1	The Netherlands	1	
New Mexico Authority	1	Sweden	1	
The Withe House Washington	1	Australia	2	
U.S. Department of Defense	23	United Arab Emirates	2	
		Germany Space Agency	2	
		Brazil Space Agency	2	
		ESA	1	
		Beijing Institute of Technology	1	
		European Defense	1	

Statement on innovation:

The data collected shows the following analysis (table 12). This is difficult data to interpret because it regards only a clear statement of the company according to what they report on their website or social media channels. For this reason, companies could be innovative but do not state it in their internet channels. According to the analysis, the ratio is 2,26 between the “yes” answer and the "not specified" ones. The data has ambiguity inside it because it is the single company that decides to state it or not. But, taking into consideration the technological focus of the sector together with other parameters of data collected, 15 “yes” in an ecosystem of 49 actors is read under a positive perspective. Expectations were describing a relation of the ecosystem with innovation that would highlight absorptive capacity. Under this view, no final conclusion can be given only with this data, but a suggestion of confirmation with further analysis can be made.

Table 12 Direct statement of innovation

Statement of innovation	Numbers of organizations
Positive statement (yes)	15
Negative statement (no)	34

Employees number

Table 13 is obtained by analyzing the data of this parameter.

According to the description, it is possible to see that the majority of firms enter under the category of the large enterprise. Medium enterprises represent an important number as well, while small and mega enterprises register almost the same quantity. Looking at the expectations a similar result was attended. Space is a complex sector that requires the development of complex infrastructure, manufacturing, and research, and for this reason, it is understandable that most companies have medium and large dimensions. The mega enterprise refers to big corporations that operate in several sectors and markets, leaders of the US industry like Boeing. For this reason, it was an aspect to find corporations with over 25000 employees, this is also justified when looking at the history of the sector and the big investment made in the 1960s and 1970s compared with the date of the

foundation of these companies. Small enterprises are also explained, referring to those companies that operate in niche markets or operate in specific scientific programs.
Employment numbers are not enough to determine the dimension of a firm, but there are indications. Applying the analysis of the data to the factors of collaboration and competition inside the ecosystem, a level of equilibrium is suggested. Small and medium enterprises need to collaborate with other components of the ecosystem to provide their products and service, as well large and mega enterprises need clients. Large and mega enterprises create competition between each other by the same interest of markets. But, what is found is that from the data emerge that NASA is the orchestra of the ecosystem, and so for big programs such as Artemis, make large and mega enterprises collaborate and compete to get NASA grants. This data suggests that besides the dimension of the single organization, is NASA and other orchestrators that regulate the level of collaboration and competition inside the ecosystem.

Table 13 dimension of organizations based on the number of employees

Categories of organizations	Numbers of organizations
Not specified	1
Micro enterprise (from 1 to 9)	0
Small enterprise (from 10 to 49)	6
Medium enterprise (from 50 to 249)	12
Large enterprise (from 250 to 24999)	25
Mega enterprise (over 25000)	5

Year of foundation:

By analyzing the data of this parameter is first obtained table 14. This table shows that most companies are founded during the new space era. Table 15 makes a second distinction inside the new space period, by adding the difference between first-generation and second generation.
From the above the conclusions that follow are that, as it was expected, the new space companies are a bigger number compare to the old space ones (the ratio according to the data is 1 on 2). As

described in the theoretical framework, begging from the 2000 thanks to technological development that cut down accessibility cost, as well as change on an institutional level delegating manufacturing activity on the private sector as well partnerships with NASA, the number of actor in the ecosystem increased. This is explained on a policy level as well by the 2015 “Commercial space laugh competitiveness act” by President Obama. According to the data, it is also confirmed that the space ecosystem is growing. It is possible to state this, when observing that in the last decade 19 new companies took part in the ecosystem, a bigger number than ever before in history.

Table 14 companies and year of foundation

Year of foundation	Numbers of companies
Old space companies (founded before year 2000)	16
New space companies (founded after year 2000)	33

Table 15 first and second generation new space

Types of new space companies	Numbers of companies
First generation (from 2000 to 2009)	14
Second generation (from 2010 to present)	19

Geographical locations:

According to the data collected, the following description is made. Table 16 shows the numbers of organizations for each US state. Table 17 shows the cities with more than one organization based.

From the data emerge that, as expected, the state with the highest amount of organization is California, followed by Colorado, Virginia, and Florida. California, Virginia, and Florida are all states that have NASA facilities, and this can be an explanation of the reason why organizations have their headquarters in the area. Colorado does not have NASA facilities, and yet an important number of companies have headquarters in the state, this requires further investigation. Texas has fewer companies base as expected, but Huston (together with Tucson) is the US city with the higher number of companies based. For Hutson, the reason for the high presence of companies can be explained through NASA's presence, while Tucson can be explained by the presence of the Arizona Space Grant Consortium.

Table 16 Geographical distribution of US Space companies

US State	Number of companies
Illinois	1
Maryland	1
Colorado	7
Alabama	1
Virginia	5
Florida	5
California	10
Pennsylvania	1
Nevada	2
Washington	2
Texas	4
Arizona	3
Massachusetts	1
New York	2
Lousiana	1
Kansas	1
No-US Based	1

Table 17 Cities with more than one Space Company

City	Numbers of companies
Tucson (Arizona)	3
Vienna (Virginia)	2
Long Beach (California)	2
Huston (Texas)	3
Mojave (California)	2

Summary of conclusions quantitative analysis

1. Sub-sector: expectation confirmed

From the analysis, it is concluded that the major economic activities of the sector are the direct manufacturing of technologies and infrastructure combined with space accessibility.

2. Specialization: expectation confirmed

Space accessibility, space flight technology, space humans needs, data and observation, science, and space exploration, are the major specialization that reflects the sub-sector. Specialization as security and energy/fuels leave open questions.

3. Economic activities: expectation confirmed

The analysis shows the analysis between hard products (technological infrastructure and hardcore technology), and soft products (software and service). Applying the point system, the analysis shows 35 points compare to 25 in favor of the hard product. The result reflects the finding of the specialization and sub-sector parameters, confirming the expectations.

4. Program involved: expectation confirmed

NASA programs have a relevant role in the ecosystem. Artemis results as the one that involves more organizations. This suggests that NASA is trying to develop the sector towards a long-time-development based on the infrastructure.

5. Ownership: expectation confirmed

Private ownership is the most common, followed by public share.

6. Alliance and partnership: expectation confirmed

Most of the companies inside the ecosystem have partnerships. Most of these partnerships are inside the space ecosystem and US market, but also international collaboration are present. This confirms the global aspect of the space sector.

7. Sector of interest: expectation confirmed

Entrepreneurial activities are the major economic interest. This suggests an important switch in the sector, in which space companies are self-developing space enabling the creation of demand.

8. Relationship whit NASA: expectation confirmed

NASA has direct relations with an important number of companies. The ones that do not have direct relations, have indirect ones.

9. Institution: expectation confirmed in part

NASA results as the institution with the major present as expected. Following, military institutions show the biggest interest, also on the international level. This suggests that space is seen as a strategic sector from a geopolitics and security perspective.

10. Statement of innovation: expectation confirmed

The results from the data collected, even if ambiguity is present, were considered satisfying. Following this data suggests an absorptive capacity of innovation inside the ecosystem.

11. Employees number: expectation confirmed

The analysis placed most companies under medium and large enterprise. This can give insights into the level of collaboration and competition inside the ecosystem. But, under this perspective it is suggested that it is NASA that regulates the level of collaboration and competition inside the ecosystem, using the programs and funding related.

12. Year of foundation: expectation confirmed

The majority of companies are founded in the second generation of “new space”. This data confirms growth of interest in the sector as reported in the theoretical framework.

13. Geographic locations: expectation confirmed in part

The data confirms that NASA facilities play a role in the setting of companies headquarters. What can be questioned is the high number of companies in Colorado, a state without NASA facilities.

Data traceability

All the data analyzed in this chapter and by which conclusions are given can be found here. In the file a table with the thirteen parameters is present, and data from each company taken into consideration is reported. Under the table, you can find a list of companies (the ones taken into consideration), and for each company notes and links from which the data was taken. How to track the data: choose the parameter that you want to verify, go to the relative company, and through the different links it is possible to go back to the source from where the data come from.

Appendix B: qualitative analysis

From the quantitative analysis, several questions emerged. The analysis suggested some conclusions, yet it was not sufficient to track the process and dynamics involved in those conclusions. For this reason, further data and analysis were needed. What I did was formulate a questionnaire in which emerged 17 questions (click here for the questionnaire). To answer the questions, I choose to interview experts in the sector. The reason for the choice of this type of methodology was due to the type of knowledge that I was searching for, and to know the opinions and views of people working every day in the sector. This type of knowledge as the measurement of motivation, power dynamics, decision making, collaboration, and strategy between actors, is quantitatively difficult to measure. Thus, the decision to use interviews as a methodology strategy.

Due to privacy reasons, my interviewee prefers to stay anonymous. What I can share is that they can be considered experts in the field due to their daily work as economic researchers in the US Space Economy sector, working for a governmental research institute.

Following it is presented the analysis and interpretation of the data gathered from the interview (click here for all the script of the interview).

Analysis

The scope of the use of interview is to gain further insight on the topic of analysis. The insight are given by those type of underlined and indirect knowledge (as sensations, views, personal integration) that would not be possible to gather by just looking at numeric and text data. This type of methodology is important for the enquiry of this less tangible aspects that are involved in the research. At first, the set-up of the interviews was consisting of multiple interviewee coming from different social groups of the sector. Unfortunately it was difficult to respect this type of starting set-up. It resulted difficult to find and schedule interviews, and at the end just one was carried out. The interview was designed as an individual semi-structure type. This means that was carried at one-to-one (interviewer and interviewee) with a pre-designed set of questions. Each question was leaving space for elaboration, this was an important aspect of the interview questioner because it gives structured based but with freedom of elaboration to gain further insights.

The script of the analysis is divided into ten points. Point one describes the methodology through which the information shared in the interview is based from. The aim is to provide traceability of the data. Point two is an introduction to the context of the US space ecosystem given by the interviewees. Point three describes the relationship between NASA and the Department of Defense. Point four analyzes the role that banks have inside the ecosystem. Point five describes the role that universities have. Point six talks about the importance of epistemic communities inside the space sector. Point seven analyzes and defines the motivation of the sector. Point eight discusses the strategy inside the ecosystem. Point nine is about the competition inside the sector and its regulations of it. Point ten discusses the innovation process from a business and economic perspective.

1. Methodology and data

The information on which the interview was based comes from data and parameters from 2019. The statistics of the data are based on a gross output matrix. The idea behind the statistic is to measure the gross output of the US Economy and which part of it is specific to space. Gross output is meant the total revenues and sales. And the way to look at this is to look at the products, and so the goods and services sold in a year for each industry that makes the sector take their story from production to the market [Speaker 1; minute 00:00:11].

2. Contextualization of the US Space Sector

The data produced say that the US Space Economy has a total gross output of $194 billion [Speaker 1; minute 00:01:44]. The biggest industry is manufacturing with the production of satellites [Speaker 1; minute 00:01:44], rockets, more in general the space infrastructure needed for the development of the sector. The second biggest sector is information [Speaker 1; minute 00:01:44], and so it is related to the service. An interesting sector that the input-output matrix shows that is growing is finance. The reason behind this data is not due to an increase in investment, but as finance relates to insurance [Speaker 1; minute 00:01:44]. The increase in insurance inside the sector is due to the regulation system that the USA has on every object that goes into space [Speaker 1; minute 00:03:31]. Government is another big industry in the sector [Speaker 1; minute 00:05:37]. Besides the big role that the government has, we are seeing a tendency from government agencies such as NASA, and the Department of Commerce, to get away from government production and encourage private production [Speaker 1; minute 00:36:35]. The reason for this is due to the efficiency that the private has compared to the public due to no governmental bureaucracy [Speaker 1; minute 00:36:35]. In general, it is possible to create a distinction in the single industry in which private and public operate. The private is more interested in market-related activities and commercialization, and so a big presence is found in service. On the other hand, the public is interested in government activities for the state for example the defense [Speaker 1; minute 00:31:39]. But the two are not separate and actually, there are co-dependent and co-evolve. For instance, in 2015 there was the peak of satellite television broadcasted by private companies, and most clients were living in rural areas. Then the government expanded the internet broadband, and so people started to prefer to use the internet compared to satellite [Speaker 1; minute 00:36:35]. On the other side, when SpaceX started the only client was the government. But now, also privates are starting to buy from it, but this was possible only thanks to the information and skills that the company learned when the only buyer was the government [Speaker 1; minute 00:38:10]. Without the participation of the government, SpaceX would not had develop this transfer of knowledge. From this it is possible to draw a short story: at the start, the government was a big part in establishing and developing the space sector. But now, in terms of new products, it seems that there is a push to get more private companies to produce with the idea of also diversifying the field.

3. Relationship between NASA and the Department of Defense

The military and defense are a pretty extensive part of space [Speaker 1; minute 00:17:29]. This is supported by the fact that there are both military organizations as the Air Force and Space Force, as no military but still defense organizations such as the Missile Defense Agency and federally funded research and development centers founded for R&D purposes [Speaker 1; minute 00:17:29]. Is difficult to track all the information and activities that the military has in the sector because most of the information is classified. But what is important is that every institution has its functions and interests. This it is meant that NASA and the Defense are separate [Speaker 1; minute 00:21:04]. If the Defense has some space project to develop it will take care independently of it using the Defense budget instead of NASA.

4. Banks in the US Space Ecosystem

As previously mentioned banks play role in the sector because of the need for insurance. Generally speaking, banks are risk averse, and when there is a risky activity is less likely that a bank is going to give money to a company [Speaker 1, minute 00:22:58]. Relating this statement to the US Space Sector, it can be said that it is likely that banks will steer away from smaller companies because the investment is riskier. On the other side, bigger companies would have more power and background to ask for investment from a bank [Speaker 1, minute 00:22:58].

5. The role of universities in the US Space Ecosystem

Universities play an important role in the development strategy of the US Space ecosystem. Universities are considered federal centers for R&D and most of the funding comes from NASA or the Science Foundation [Speaker 1, minute 00:25:11]. Universities have several roles inside the ecosystem, but an important one can be considered the one of explorative innovation. The strategy is to send money to universities and have college students explore a certain idea or topic [Speaker 1, minute 00:34:46]. The students can do preliminary work in which they figure out the pros and cons, highlighting where and if there is the possibility for money, and challenging the potential of the idea. This is because students are unpaid labor, fitting the needs for the starting phases of the process [Speaker 1, minute 00:34:46].

6. Epistemic communities inside the US Space Sector

As a starting point, the US Space Sector is relatively small, thus also its community. From this, it is plausible to state that most people know each other, and even more plausible they talk. The activity of the community is related to the type of innovation, new products, and services that are being made in the sector. Related to these epistemic communities is the fact that new companies that enter the sector do not come out from anywhere. Commonly, new companies are started by people that before were working already in the sector as in SpaceX or NASA [Speaker 1, minute 00:26:45] . It is plausible to say that inside this process in which people already in the space community start new companies and activity there is also the innovation drive of the sector. And, geographically, the already existing presence of space facilities, knowledge centers, infrastructure, etc. influences the choice of the location for a new plant [Speaker 2, minute 00:28:04].

7. The US Space Sector motivation

Related to the community there is another important factor: motivation. Generally speaking, it can be said that the motivation inside the US space sector is shared with similar features between all its parts. The motivation can be read as the production of a bigger American “dream”. This dream is a cultural phenomena, and it can be divided into two parts, that are part to what is generally known as American culture [Speaker 1, minute 00:29:00]. The first aspect is the desire for discovery [Speaker 1, minute 00:29:00]. Most conferences or speeches of today about space start with the story of "when I (i.e. the speaker) was a child and saw the Moon landing"[Speaker 1, minute 00:29:00]. It can be stated that the period of the Moon landing and the space race had a big impact on American culture. Becoming a symbol of technological advancement for the nation as well as fueling and shaping imagination. On the other hand, there is the opportunity and business side of space [Speaker 1, minute 00:31:39]. The famous statement of America as the land of dreams can be linked to the American culture of the entrepreneurial spirit present in many sectors (e.g. think of Silicon Valley) as in the space sector. The entrepreneurial push of the sector is also proved by the government regulations that are promoting the commercialization of space. This leads to a potential growth area [Speaker 1, minute 00:31:39]. From these factors, it can be seen that the motivation inside the US Space Sector is shared between its actors as the result of the context in which it emerged (i.e. the American culture).

8. The strategy of the US Space Sector

The motivation element is linked to the strategy. Concerning the strategy, it was described in point 5 the role that universities have. The quantitative analysis has shown that most companies are involved in NASA programs. The programs have the role of guiding the development of the sector. The development is stimulated by the private companies that collaborate and compete with each other to get the fundings that NASA delivers to the programs. During the quantitative analysis emerged that also a private company (I.e. Google) had created its space program (the Google Lunar Award). From this, a specific question was asked in the interview, and this was about the interpretation of this event and its meaning for the sector. For the interviewees, the Google program is not a big shift in the sector, but it is a signal of the importance that the space sector is getting in the US Economy [Speaker 1, minute 00:34:46]. From this, is possible to interpret that the creation of private space programs with related funding and grants, is not a shift of paradigm in the working of the sector. But it can be considered as the emergence of the gradual change towards commercialization that space is having in the US context [Speaker 1, minute 00:34:46].

9. Competition and regulation inside the US Space Sector

Competition and regulation are elements that depend on the activity that companies or organizations are doing. The major part of the government as a regulatory authority is to collect taxes [Speaker 1, minute 00:40:29]. But it has also regulations concerning safety measures and responsibilities as to what can go in space and insurance [Speaker 1, minute 00:01:44]. From this can be stated that government regulations concern the general features and structure of the sector instead of specific dynamics. From this emerges competition. Because there is no top-down regulation on what concerns the manufacturing and R&D of components and new technologies, competition between companies is free. This is to say, with an example, that if company X is developing a new type of rocket, and several companies present their new engines, there is no regulation in the decision process that leads to the choice of the engine [Speaker 1, minute 00:40:29]. In this sense the supply between companies is free from regulation, stimulating competition.

10. Innovation process inside the US Space Sector

Every point that was described is part of the innovation process that takes place in the US Space Sector. For this point, there is a focus on four aspects of it. In the bigger picture, the four points are interlinked. The first point is the private and public partnership that takes place during the innovation process. Most of the innovation activities are made by private companies financed by government money. Making the government the biggest customer of the privates, creating this process in which the government that is pushing the private to participate inside the sector [Speaker 1, minute 00:38:10]. The reason why government agency as NASA, Space Force, and the Department of Defense, are encouraging commercial private companies to enter the sector is that privates are more efficient in creating innovation compare to the public due to fewer regulations [Speaker 1, minute 00:36:35]. From this, there is the tendency that private companies to try to innovate even more to get government funding, and so this type of ecosystem structure stimulates the innovation process [Speaker 1, minute 00:38:10]. The second point is that there is a distinction between private companies. Most of the actual product is made by big companies such as Boeing, Lockheed Martin, SpaceX, etc. but also small companies are part of the ecosystem. Small companies most of the time go bankrupt or get absorbed by bigger companies [Speaker 1, minute 00:10:38]. In both cases, there is knowledge transfer implied in the transition process of the companies. If a big company absorbs a little one, then also knowledge gets absorbed, and it can stimulate innovation. Third, is difficult to say how much of this innovation has market application, and so measuring the return of investment. The interviewee said that the Department of Commerce has started recent research to look inside this return on investment [Speaker 1, minute 00:13:51]. But at the moment the research is still under development. Forth aspect regards the knowledge trajectory inside the innovation process. It can be assumed that the activity of R&D that private companies have done for the government as a customer is now used for private customers [Speaker 1, minute 00:38:10]. Making an example: if company X started their activity with the government as a customer. Their knowledge and development as a company was created during the period in which the government was the customer. Then, after the company developed a certain methodology, know-how, relations, practice, knowledge, etc. are now using all this type of information (tangible and abstract) for private customers. Leading to a knowledge trajectory that starts with the public and then matures with the private.