LUISS

Department of Impresa e Management
Double Degree in International Management (DDIM)
Chair of Entrepreneurship and Venture Capital

Innovation in the Space Economy: Can Emerging Newcos and Startups Disrupt the Industry and Reshape the Competitive Environment?

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Academic Year 2020/2021

Abstract

Sustained commercialization in space economy has generated new business opportunities and it is attracting an increasing number of newcos. The newly emerged competitive environment is characterized by fierce competition at all market levels, with major newcos challenging incumbents at high-end and mass segments, and other startups targeting low-end and new-end verticals. Increased capital accessibility is also allowing such entrants to develop and implement innovative solutions that could potentially reshape space economy's entire paradigm. The RLV segment provides several contingent examples. Specifically, Sidereus' business case shows how a startup could potentially disrupt the whole industry starting from the very bottom of the market.

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2 Introduction

The thesis of this paper is that emerging space newcos and startups can potentially disrupt space economy and reshape industry's paradigm. Literature review starts from the theoretical difference between creative destruction and disruptive innovation, which define the framework of the discussion.

First part of chapter one provides a comprehensive perspective on space economy's evolution concerning market dimensions and characteristics. In detail, contribution to revenue generation from public and private sectors is extensively discussed. Estimates on industry's turnover are also reported to reconstruct space economy's performances over the last 20 years. Morgan Stanley's study on space business is finally presented to draw forecasts for the next future.

Second part of the chapter focuses on the level of public and private investments. In detail, OECD overall investments over the last 20 years and increasing commitment from institutional investors will be reported. Concerning private endeavors, detailed analysis on capitals addressed to new space ventures will be developed aiming at identifying main sources of financing.

Third part of the chapter provides a linear regression model to identify main factors affecting the entrance of innovative startups, and to possibly portray trends for the next future. Contingency on emerging newcos will then be presented through SpaceX's metrics and records.

To conclude, effects of commercialization and considerations on the mutating competitive paradigm are derived.

Second chapter presents New Space's emerging segments, with an extensive focus on the satellite launching sector. Specifically, RLVs market for small payloads is described, with a focus on current solutions offered by major newcos operating in the segment. Then, CubeSats' increasing prominence is discussed through data and records, and emerging low-end business opportunities are presented. In detail, current inefficiencies due to cost and operational unfitting are reported, and untargeted footholds are identified.

Chapter three provides Sidereus' business case, serving as a practical example to understand how entrants are tackling such emerging opportunities, how they are dealing with fierce competition, and which factors may be leveraged to generate innovation. Specifically, competitive environment, VP strategic implementation, and main tech features determining competitive advantages are discussed.

Conclusions are eventually derived and confronted with the theoretical framework initially defined.

3 Methodology

Literature review relies on publications regarding cited theories, namely the creative destruction and disruptive innovation. The reconstruction of space economy's commercialization is instead developed through papers and articles from space entities such as OECD, Bryce Space and Tech, Space Capital, or from scholars. Similarly, qualitative analysis and considerations on current scenario are built on disclosed acts from involved parties, and on articles and interviews from major space and tech websites like space.com and techcrunch.com.

Regarding datasets, main issues concerned data availability. Specifically, observers only recently begun collecting industry's metrics systematically. Consequently, even mainstream indicators such as space economy's overall turnover have a narrow range of observations. Furthermore, not all space segments are properly defined and monitored, leaving several verticals untraced. Such contingency eventually required some datasets to be furtherly worked up. To deal with these structural limitations, datasets used in the paper are only taken from public and private institutions that make official disclosure and that provide full references of their materials, such as: The Space Foundation, Satellites Industry Association, nanosats.eu, crunchbase.com.

Latest section concerning Sidereus' business case has instead been developed after several interviewing sessions and calls with Luca Principi, COO and co-founder of the company.

4 Literature Review

Space economy is a high-tech industry that operates at the frontier of technology and innovation. The sector is currently expanding, and incumbent entities are benefitting from growing demand and increasing business opportunities. However, the ongoing and sustained commercialization process is also allowing several newcos to enter the industry and to provide innovative solutions at different levels of the market, possibly altering established competitive dynamics. This contingent scenario portrays a dynamic environment which might be subject to dramatic changes over the next few years.

Scholars have historically dwelled upon innovation theories. Several models and frameworks have been developed trying to explicate how innovation occurs, and to identify and categorize which key factors most innovative companies do (or do not) share.

One of the first and most recalled theories of innovation is the "creative destruction" enunciated by Schumpeter in mid of the XX century. It portrays innovation as a "process of industrial mutation that continuously revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one" (Schumpeter, 1942). In such perspective, economic and technological development are innovation-driven processes that uniquely shape and distinctly characterize occurring business cycles.

Schumpeter's gale firstly captured the destructive component that belongs to some kinds of innovation. Successively, such component was furtherly investigated by Clayton M. Christensen and his collaborators, resulting in the first enunciation of "disruption". The concept, which roots in creative destruction, describes a process whereby a smaller company with fewer resources successfully challenges established entities either by servicing untargeted segments of the market, or by turning noncustomers into customers (Christensen, 1995). Specifically, while incumbents target the most profitable (and demanding) segments of the market offering incremental solutions, entrants that prove disruptive begin focusing on neglected pools and introduce and validate alternative (possibly cheaper) solutions. If entrants are able to move upmarket and acquire significant shares of mainstream customers while preserving the advantages that drove their early success, disruption has occurred, and incumbent players have to adapt not to get outplaced from the market. The newly emerging competitive environment is eventually characterized by completely new benchmarks and dynamics, and by increased accessibility.

Hence, in Christensen's orthodox formulation, innovation can be defined as disruptive only if it originates in low-end or new-end footholds. Such classification has been criticized by other scholars which define disruptive also companies that are able to reshape the competitive environment and to increase overall customer base starting from high-end or mainstream segments. The counter argument

is that disruption is not just an outcome, but rather a process during which the entrant upscales from marginal or untargeted segments. However, it might also be the case that these marginal or untargeted segments may be at the very upper side of the market.
Apart from academic debate, innovation that dramatically changes an already existing competitive environment by exploiting new technologies or business models might be defined either as creatively destructive or disruptive according to the degree of theoretical strictness applied, and depending on how low-end and new-end footholds are defined.

Concerning space economy, the industry proves valuable to furtherly discuss about creative destruction statement and disruptive innovation theory (both orthodox and apocryphal versions), with the goal of understanding whether entering newcos will be eventually able to creatively destruct – or possibly disrupt – the whole space industry.

5 Effects of commercialization on the competitive scenario

The purpose of this chapter is to depict the evolution of space economy's competitive scenario over the years, and to emphasize how recent developments are dramatically changing both investment patterns and interactions within the sector, with focus on emerging newcos and startups. In detail, main factors potentially affecting investment level in new space ventures will be discussed and jointly analyzed through a multilinear regression model. The final goal is to understand which parameters significantly affect the number of space ventures accessing capitals.

5.1 Space from the beginning

Space exploration roots back to the middle of 20th century. Right after World War II, Soviet engineers began developing artificial satellites aiming at furtherly implementing rocket technology for long-range missiles. An initial developmental plan was proposed and approved in 1954. The first successful launch happened few years later, in October 1957, with the Sputnik 1. The satellite orbited for three months around the Earth collecting relevant scientific data and becoming a driver of Soviet propaganda. A follow up launch was then scheduled and successfully executed with the Sputnik 2.

Soviet's consistent results unsettled the American public, who had also assisted to the televised failure of Vanguard TV-3 at the end of 1957. After that, the US government began addressing greater concern and increasing funds to scientific and technological research aiming at developing satellites and rocket engineering to challenge Soviet's leading position. Nevertheless, Soviet Union accomplished the first manned spaceflight in April 1961, sending Yuri Gagarin into orbit on the Vostok 1 capsule. In the same year, the Apollo program was approved by the American Congress, setting the goal of bringing man to the Moon, officially starting the Space Race (Mann, 2019).

Despite lagging, US kept on devoting enormous funds and effort to the quest, speeding up in the Race and recovering the technological gap. Americans were indeed able to achieve significant records, eventually landing the first human being, Neil Armstrong, onto the Moon with Apollo 11 in July 1969. Follow on missions were executed between the end of 1969 and 1972. However, incoming budget cuts severely downsized subsequent programs and space exploration plans slowed down.

On the Soviet side, Moon landing was never achieved: N1 project incurred several failures between 1966 and 1972, being officially terminated in 1976.

Moon landing somehow closed the Space Race and set off USA's leading role at the frontier of technological innovation. The quest, fueled through massive governmental investments, left a deep and scattered technological legacy that sparked within different fields and disciplines. However, space exploration and the related economy mainly remained within governmental boundaries, being managed through governmental organizations, and relying on the amount of funds allocated by central governments. In general, most developed countries began developing their own national space agencies and drawing international co-operations.

Post-Moon-landing projects mainly concerned implementing orbital space stations. URSS launched Salyut 1 in April 1971, USA dispatched Skylab in May 1973. The two space agencies also had the opportunity to plan a joint mission, the Apollo-Soyuz Test Project, which was successfully executed in 1975: the American module docked in orbit with the Soviet capsule, allowing the crews to run joint experiments and to visit counterpart's spacecraft.
ASTP laid foundations for the International Space Station. Indeed, NASA and Roscosmos[1] (the post-URSS Russian space agency) played a crucial role in developing and coordinating the inter-agencies project that also involved ESA (European Space Agency), JAXA (Japanese agency) and CSA (Canadian agency). Orbital assembly procedures began in 1998, the first crew was hosted in November 2000. All modules were delivered by the Space Shuttle.

The Space Shuttle program is another milestone in space history. It was started by NASA in 1972. It aimed at developing a reusable space transportation system for Earth-to-orbit missions, and it was conceived to sustain one launch per month, for totaling about 150 launches over a 15-year operational span. First mission took place in 1981, and the craft served until 2011 (NASA, 2017). The Space Shuttle program allowed consistent cost reduction, that was furtherly enhanced through standardization and optimization of processes among different space agencies. Space Shuttle missions have included iconic projects such as the development of the International Space Station, carrying and servicing the Hubble Space Telescope, the Ulysses, Galileo, and Magellan interplanetary missions.
According to NASA estimates, the total cost for the 30-years life span of the program is about $196bn (in 2011 US Dollars), with an average cost per mission of $450mln (2011 adjusted).

5.2 The entrance of private companies

The file rouge among the above-mentioned missions, programs, and achievement, is the prominent role of national governments, with the public sector being the main, almost the sole, investor in space projects. Researchers emphasize how "Space industry was enabled by, and grew because of, institutional customers" (Hiriart, 2009). Indeed, the enormous investments required, the stringent regulatory environment, in addition to the deep and comprehensive technological competence needed to plan, develop, and implement a space program, appeared as too high entry barriers for the private

[1] Founded in February 1992, it is responsible for Russian space projects and research.

sector. Nevertheless, a first milestone in private spaceflight was posed by Orbital Sciences Corporation. The company was incorporated in 1982 and began offering side-services to NASA for maintaining small satellites. Few years later, Orbital received huge financing from NASA and DARPA[2] to develop Pegasus, the first private rocket to reach space. Pegasus was successfully rolled out in 1990 and became a solution for affordable and reliable small launches (Northrop Grumman, 2020). It served until 2019, counting 44 missions and 95 satellites dispatched.

The newly proved reliability of private spacecrafts (and their relatively lower cost) increased the demand for private spaceflights. Companies enlarged portfolios of products and solutions, and national agencies began contracting out launches and services. In 1998 the ESA awarded a $470mln contract, which was renegotiated to $1,1bn in 2004, to the French state-owned Aérospatiale for developing the ATV[3] cargo spacecraft (FlightGlobal, 2004). The company was joined by a consortium of private subcontractors such as Alenia Spazio, Matra Marconi Space and DaimlerChrysler Aerospace that played a relevant role in developing and testing the ATV. In 2000, Aérospatiale got merged to DaimlerChrysler Aerospace and Construcciones Aeronàuticas forming EADS, today Airbus Group (Airbus, 1997-2021). Despite some delays, the ATV spacecraft was eventually launched in 2008 and served until 2014.

NASA itself turned again to private companies and subcontracted Orbital for several operations: in 2008, to deal with the looming retirement of the Space Shuttle, the agency stipulated a $1,9bn contract for cargo transportation to the ISS over the period 2011-2015. Resupply missions were flown by Cygnus spacecraft through the Antares rocket. In 2014, Orbital dispatched the ICON satellite on behalf of NASA on a Pegasus XL rocket (NASA, 2014). The launch accounted for $56,3mln and included fix-launch service costs, spacecraft processing, payload integration, tracking, data and telemetry and other launch support requirements (NASA; Orbital Sciences Corporation, 2008).

Hence, private companies initially began as subcontractors, offering a limited range of side-services to national agencies, but through such commissions they were able to acquire knowledge and technical capabilities. Moreover, fluctuating governmental budget to public space programs and the greater cost efficiency enhanced by the private sector finally boosted space economy, that literally rocketed at the beginning of the XXI century: companies began expanding, running M&A operations, and increasing investments in R&D, progressively gaining relevance within the sector, which was also sustained by the progressive commercialization which introduced an increasing number of private customers. Shove stressed out that “an interesting metamorphism is evolving in the space

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[2] Defense Advanced Research Project Agency. It directly responds to the US Department of Defense and may cooperate with NASA for projects that concern applications for national defense.
[3] Automated Transfer Vehicle launched for refurnishing the ISS.

industry as many firms begin to evolve from government-only customers to mixed customers, and finally to totally private customers" (Shove, 2005).

5.3 Space economy since 2000

The XXI century represents a watershed in industry's evolution. To properly understand the changing economic environment, it would be useful to recall P. Whitney's study that summarizes industry's commercialization process through three main stages (Whitney, 2000):

- A centralized phase of the space market (1957-1975), characterized by tight governmental control and almost no commercial application.
- A decentralized phase (1975-1990), characterized by sharp technical advances, lower cost, and emerging private companies.
- A distributed phase (1990-2000) with increased commercialization and flourishing markets.

In detail, such distributed phase was enhanced by the rapid development of national space laws aimed at simplifying the regulatory framework (also in countries with limited space operations, trying to attract FDI) and driven by communication satellites programs, with consortia and international groups competing for interrelated commercial markets arising from the deregulation of telecommunications. At this latter stage, companies begun implementing strategic corporate operations such as M&A, spin-off, and joint ventures to properly address space market's renovating regulatory environment and its growing demand.

Investments in technological development also proved crucial in such commercialization process, fueling innovation, reducing operational risks, and lowering applications' costs. Whitney (2000) pairs the evolution of investments patterns in communication satellites and launch vehicles technology (as a proxy of investment in the sector) to the evolution of space market's dynamics, identifying comparable stages:

- an initial phase characterized by centralized military and governmental domain, with public sector being the sole investor in technological development of space economy.
- a decentralized phase, with private companies providing side-services and beginning to invest in technology and optimization.
- a distributed phase, with private agents deeply involved in technological development of space economy.

Private endeavors were furtherly spurred by the previously mentioned liberalization in the communication segment, which resulted in a greater number of satellites dispatched, and by subsequent operators' major request of "smaller, cheaper and more efficient launch services". This latter trend considerably boosted R&D for reusable launch vehicles (RLVs) generating an increasing variety of COTS (commercial off-the-shelf) components. Several newcos arose leveraging such distributed knowledge and technology, pioneering in RLVs field. Some of them were Kistler Aerospace, Kelly Space and Technology, Pioneer Rocketplane (Whitney, 2000). However, at the beginning of 2000, technology appeared yet too green to shape a new stage of the industry. Moreover, barriers to entry due to financial and technological risk were still relatively high for allowing lean business models succeeding in the sector.

Nevertheless, things have considerably changed over the last decade: the industry has experienced a dramatic increase in overall turnover, and the competitive scenario has been characterized by growing interest in space ventures and in downstream applications of space-related technologies, with emerging appealing business opportunities.

5.4 The evolution of space market

Historically, space industry presents peculiar market dynamics. Space products and services can be considered as complex products systems (Davies, 2005) that are characterized by:

- Highly concentrated demand and supply structures, implying few customers and few providers acting in an oligopolistic market.
- Few large transactions, as provision of products and services is generally capital intensive, and life cycles are relatively long, eventually resulting in few yet expensive deals.
- Government strict regulation and direct administration of transactions, due to strict linkages with national defense and security.
- Negotiated prices between suppliers and customers due to low standardization of services.
- Imperfect competitive interactions among economic agents due to profound information asymmetry deriving from operating at the frontier of technology.

All these sector's identity characteristics dramatically affected space market's development. The industry has indeed been severely tied to government massive investments, with tight margin for entrepreneurial activity and private experimentation, eventually resulting in a state-controlled sector with limited means to commercialization. Nevertheless, researches show that national defense agencies have been pivotal in implementing major space technologies to daily applications (Barbaroux, 2016): investments and technological development sustained by the public sector over the years have indeed spurred innovation and progress, finally creating prerequisites for changing both market dynamics and supply/demand patterns, eventually shaping a new stage of space economy which is characterized by increased accessibility.

In order to provide a contingent perspective on the evolution of market dynamics, industry's demand structure over the years shall be considered, and three main dimensions shall be identified:

- Nature of the operator (i.e., the customer).
- Nature of the payload (i.e., the technological component that defines the effective application of a mission, such as communication satellite for TV broadcasting).
- Volume of overall demand resulting in annual turnover generated.

Barbaroux (2016) examined 1593 launches over the period 2000-2013, grouping and analyzing data concerning sector's main operators. It emerges that governmental operators (mainly national agencies) account for about 70% of the spaceflights sampled, with the remaining part consisting of both private companies and non-governmental agents (e.g., corporates, universities, research labs).

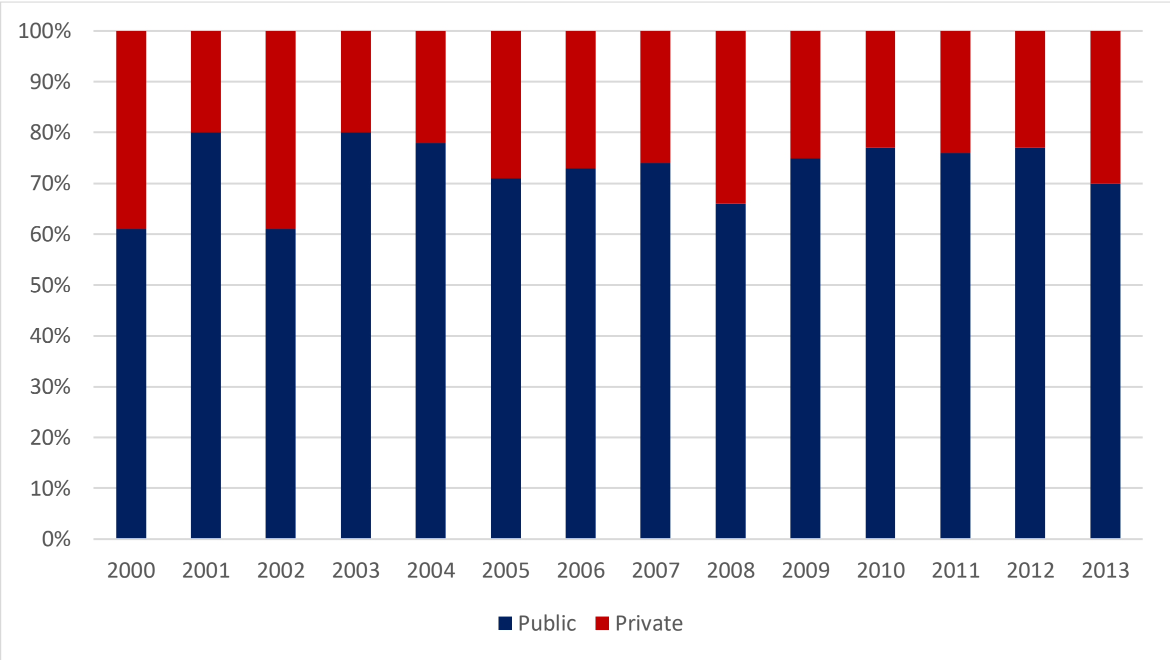

Figure 1: Evolution of public and private payloads launched (in percentages) over the period 2000-2013.

Figure 1 provides a sharp knit concerning the nature of operators across the sampled period. Specifically, a 70-30 composition clearly appears (public and private, respectively), with no clear path in variation and no relevant emerging trend.

However, despite marked prominence of governmental spaceflights, Shove (2005) stresses out that already in 2003 about 83% of total revenues generated by the whole sector came from commercial applications, which are strictly linked to interests expressed by private companies rather than to governmental operations. This proportion was also confirmed by the OECD in 2011 and only slightly adjusted over the last ten years.

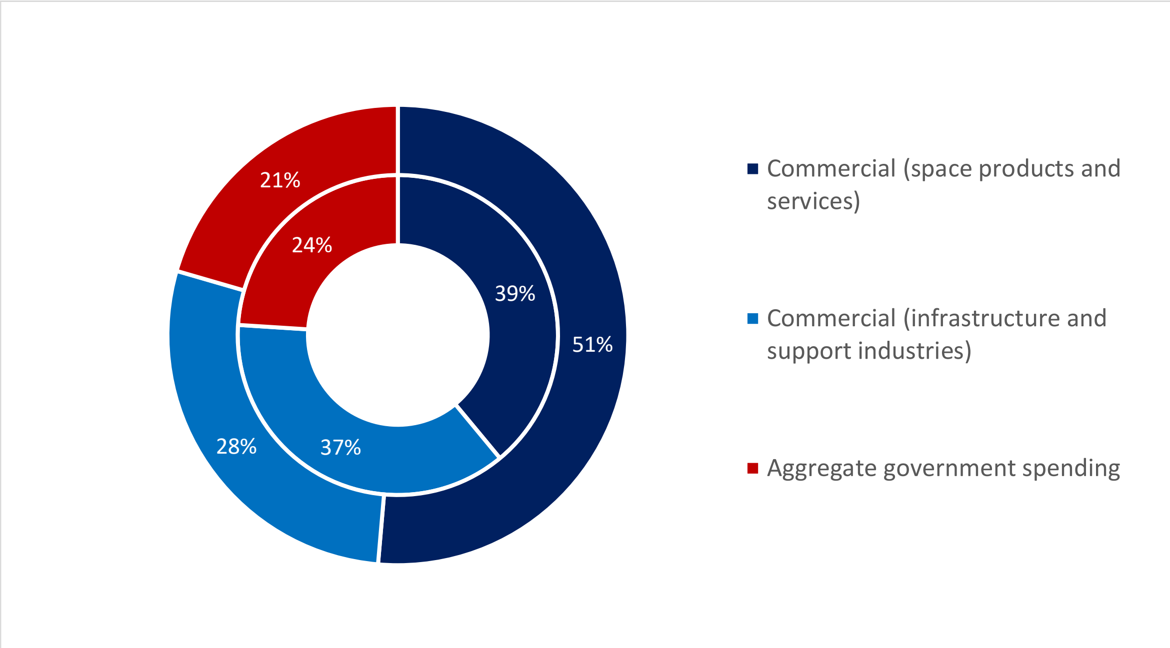

Figure 2. Composition of global space economy's turnover in 2013 (inner) and 2019 (outer), by sector and operator.

Figure 2 portrays data collected by The Space Foundation and provides a snapshot of industry's revenue composition in 2013 (inner circle) and 2019 (outer circle). The graph actively presents two points: first, the overall relative contribution of commercial (i.e. private) and public operators to industry turnover has not changed much over the years; second, more than 75% of industry turnover is generated by commercial operators, basically retracing percentages expressed by Shove's research paper in 2005. Main difference only concerns the readjustment within commercial expenditure, with some shares that have migrated from infrastructures to services.

As a matter of fact, both literature and data reported in figures 1 and 2 actively show that demand structure's composition appears quite stable since 2000 onward concerning both the nature of operators and the percentage of revenues generated by public and private sectors: whereas governmental entities are responsible for the majority of spaceflights, commercial payloads generate the higher fraction of financial transactions.

If the first two observed dimensions of space market's demand appear relatively unchanged over the years and basically depict the same macro scenario, the third and last factor is the only one that could still support the hypothesis of an evolved market environment, and eventually ground further investigations on the competitive scenario.

Indeed, despite OECD (2018) reporting that many commercial space activities are still not covered by official statistics, industry overall turnover (the third dimension of demand structure) has been booming. Space Foundation's report offers prime estimate of space economy's turnover and portrays a dramatic increase in industry overall performance, with revenues literally rocketing from $186 billion in 2005 up to $424 billion in 2019.

To allow a more comprehensive perspective, figure 3 presents data officially collected by The Space Foundation from 2005 onward (The Space Foundation, 2007) and provides an additional well-fitting tendency line to reconstruct industry performance over the period 2000-2004.

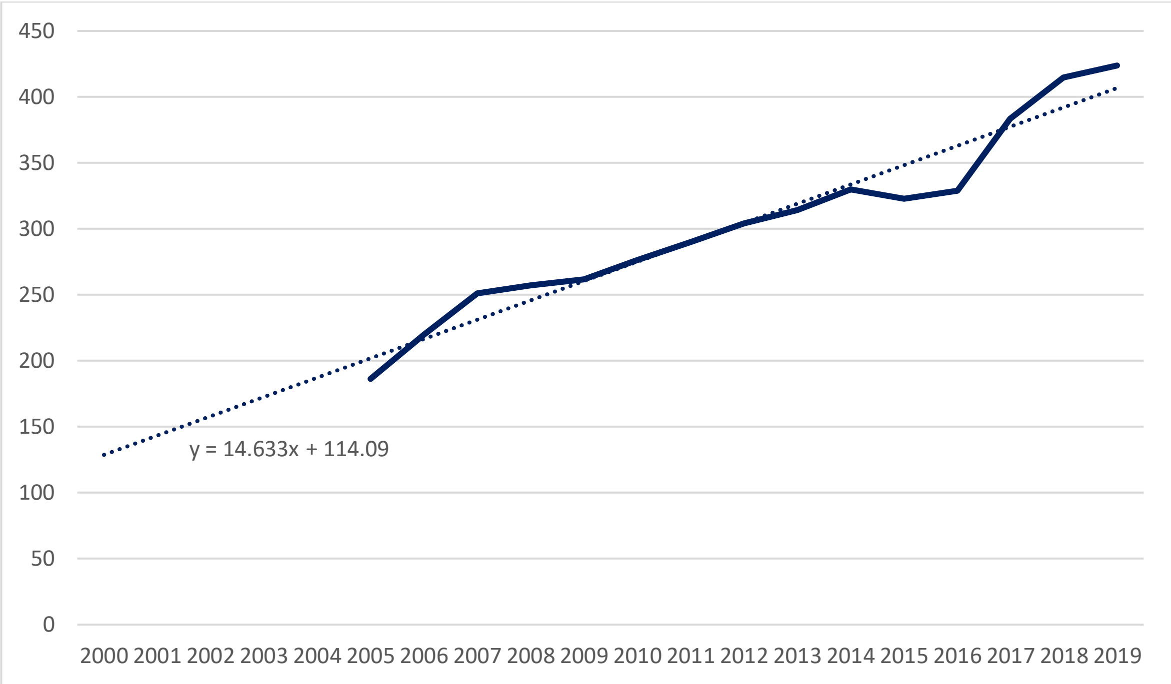

Figure 3. Space economy turnover 2005-2009 (actual estimates) and 2000-2004 (from data workup), in billion USD.

The massive growth rate (+127% in the fifteen-years period from actual estimates, which becomes +229% on a wider twenty-years period if considering the reconstructed estimates for 2000-2004) is mainly due to technological progress and to enhanced commercialization that generated downstream application of space-related technologies, allowing new market segments branching out.

In a 2020 research, Morgan Stanley investigated space economy’s frontier for the next twenty years period focusing on a baseline scenario where the sector is mainly driven by downstream applications, and particularly by cost optimization in satellite broadband internet access. Even though the study adopts an investor-concerned perspective and avoids making any prediction on emerging and pioneering upstream markets, the industry is expected to reach $1 trillion by 2040 (Morgan Stanley, 2020).

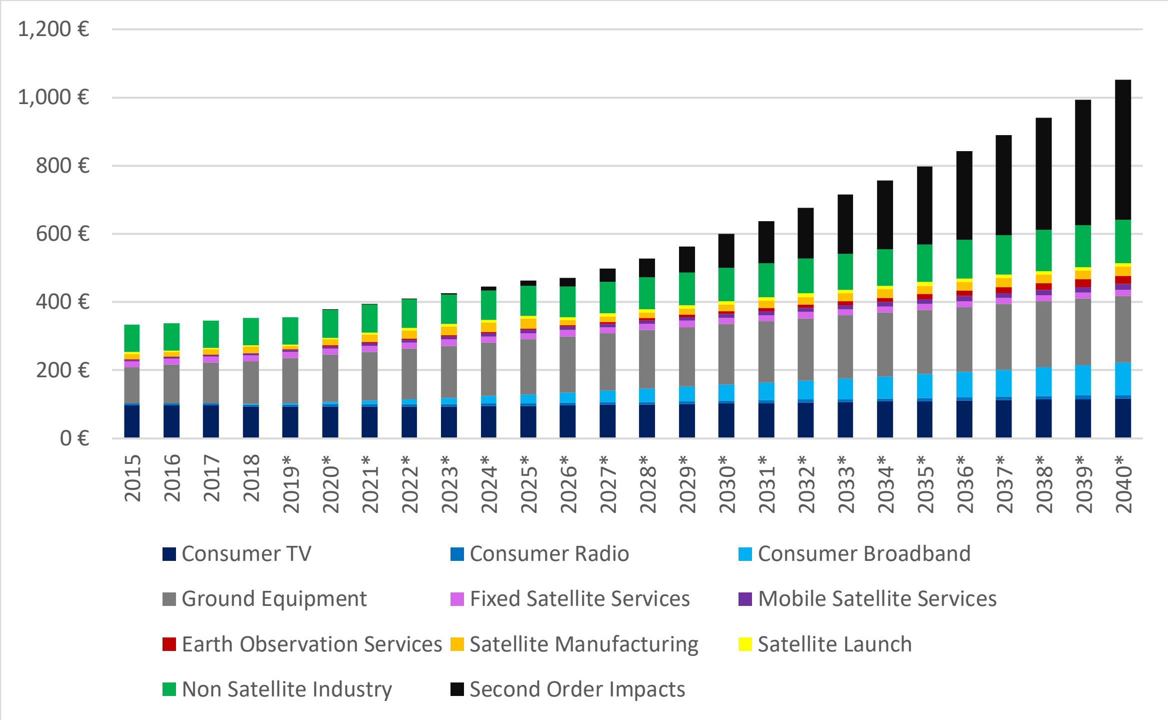

Figure 4. Industry development forecasts by Morgan Stanley.

Morgan Stanley's prudent approach also excludes current upstream space market revenues from industry records (turnover over the period 2015-2019 results lower than what is reported by The Space Foundation) and only provides a synthetic parameter "Second Order Impacts" to aggregate emerging businesses from 2024 onward.

However, the upstream development of space market could potentially lead to even more optimistic and barely foreseeable results. Merrill Lynch predicts a 3x growth rate of the industry with respect to Morgan Stanley, resulting $3 trillion of expected turnover by 2040 (Sheets, 2017). Such huge difference is mainly due to the fact that implication of future pioneering and potentially disruptive development are not accurately quantifiable from current perspective.

In the end, even if the proportion of operators' natures (i.e. public or private) and their contribution to revenue generation (70-30 composition) have remained fairly stable since 2000 onward, and even if a prudent analysis would considerably net optimistic expectations for the future, the industry already marked astonishing results, and forecasts for the next decades appear even more promising, as the ongoing commercialization process is generating several flourishing downstream and upstream verticals, untapping true market potential.

To sum up everything that has been stated so far, the pie has already grown so big to ground and justify the claim of a new stage of space economy. However, in order to provide a more contingent perspective on the sector, it is crucial to outline investment trends and patterns characterizing the competitive scenario. Evidence and analysis on this latter point are presented in the following sections.

5.5 Level of investments

Space industry operates at the frontier of technology and innovation. Such peculiar condition makes national agencies (initially) and companies (lately) eager for investments and funds to fuel their R&D-intensive projects. Considering that Shove (2005) reports changed market conditions over the years, and that Whitney (2000) identifies several distinct stages of space economy and innovation, it is reasonable to suppose that the "average space investor profile" may have evolved as well over the years according to the contingent developmental phase of the industry.

5.5.1 Public investments

Public funds have historically played a crucial role in sustaining and fueling space economy's development, with some governments addressing shares of public expenditure consisting in several hundreds of million USD. Even if governmental budget allocation might have varied over the years, top-investing countries have mostly remained the same. Figure 5 reports the shares of public expenditure devoted to space budget in sampled years (2005, 2009 and 2017) for some selected countries (i.e. countries addressing on average the higher percentage of their GDP in space R&D).

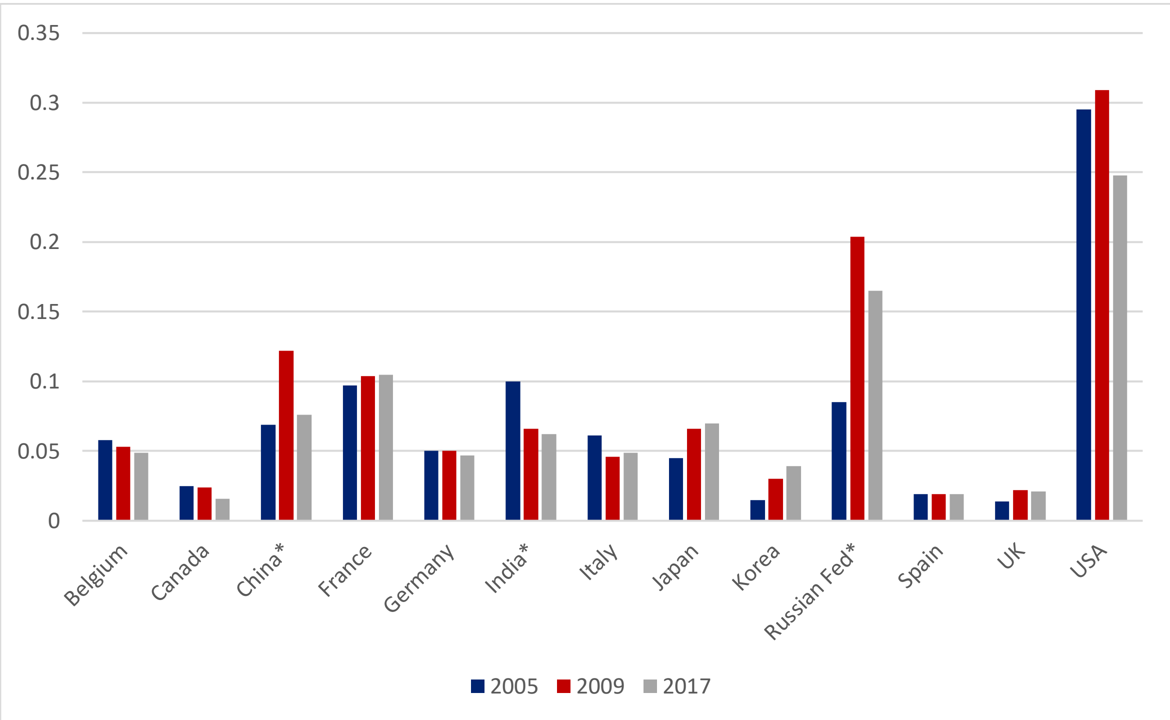

*Figure 5. Public space budget as percentage of GDP for sampled years (2005, 2009, 2017). *Not OECD countries.*

As clearly emerges, USA outdistance other countries in terms of funds committed, allocating about 0,3% of their national GDP to space budget. The figure also provides a valuable insight concerning the level of each country's commitment. However, budgets may not necessarily match actual expenditures and they are difficult to compare across different countries because they are usually vague concerning areas of investments and may generate ambiguity due to weak classification, eventually misreporting actual amount of capital addressed (OECD, 2011). To properly understand public sector's commitment in space development, a more contingent indicator shall be analyzed: the share of civil Government Budget Allocations for Research and Development (GBARD[4]) addressed by countries to space economy (space GBARD). It is an indicator proposed by OECD that synthetizes all actual R&D investments falling under the category "exploration and exploitation of space". Such category includes fundamental and applied R&D activities, and space-related infrastructures such as laboratories and launching systems. Even though some relatively important items are not included (i.e. defense-related activities, and meteorological and environmental monitoring) the space GBARD is a reliable proxy to measure and compare institutions' long-term commitment in space industry's development. Figure 6 reports the percentage of space GBARD expenditure for previously investigated OECD countries.

In the sake of a contingent and grounded analysis, previously examined not-OECD countries (which have no official space GBARD declared) are excluded from the sample.

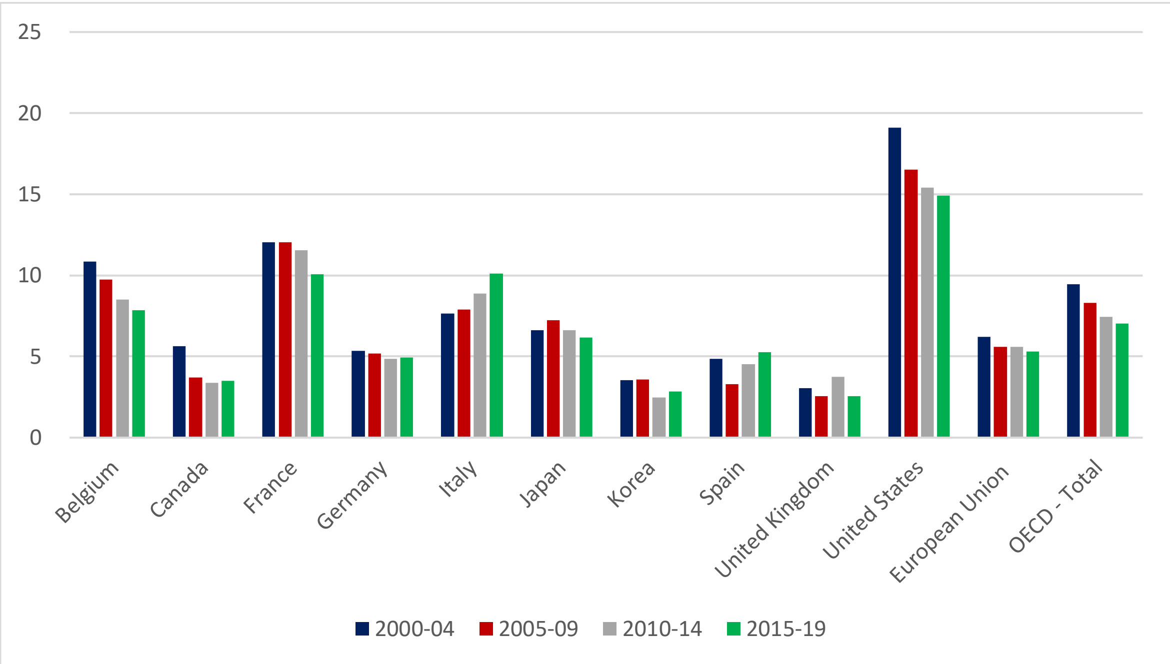

Figure 6. Percentages of space GBARD (share of total civil GBARD) for selected OECD countries 2000-2019.

[4] Government Budget Allocations for R&D (civil GBARD) encompass all spending allocations met from sources of government revenue foreseen within the budget, such as taxation (OECD, 2015).

The index clearly runs different paths in different economies. In general, the majority of countries presents decreasing space GBARDs (especially USA, from 19% to less than 15% over the sampled periods), which jointly determine a decreasing "OECD – Total". Nevertheless, USA remain by far the most committed country of the sample, outperforming space GBARD averages of OECD – Total. Figure 6 also enhances the relatively high effort from countries such as France, Belgium, and Italy (the sole countries where public investments in space have constantly increased over the sampled periods) which considerably outperformed OECD averages over the last twenty years (OECD, 2021). To provide a more explicative analysis, Figure 7 and 8 report space GBARD converted in USD monetary terms. USA, EU, and OECD – Total, are reported aside because GDP differences make absolute amounts varying significantly across different economies.

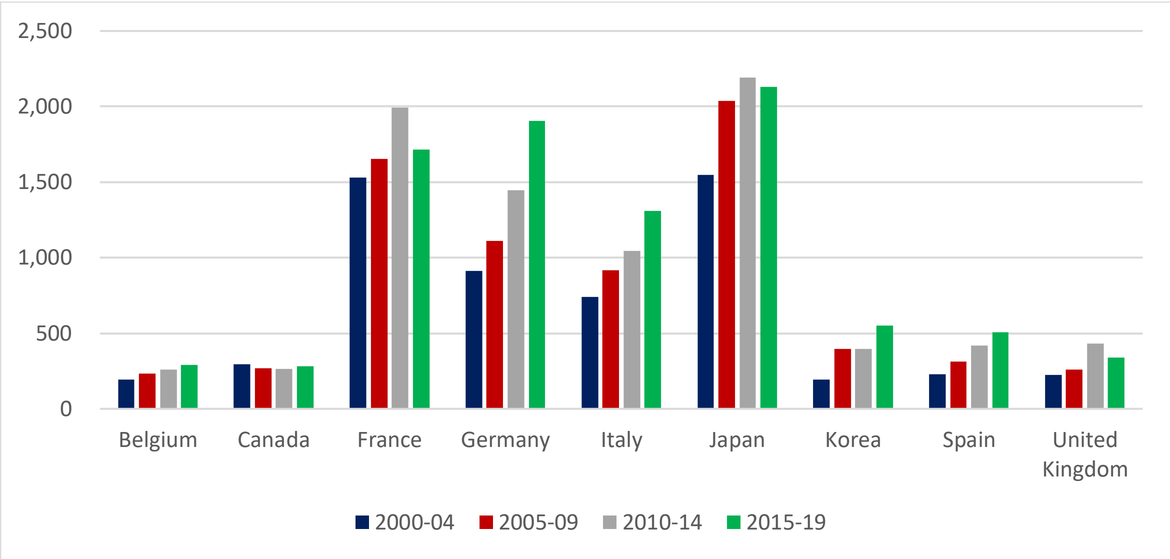

Figure 7. Monetary value of space GBARD for selected OECD countries (at current PPP$) over the period 2000-2019.

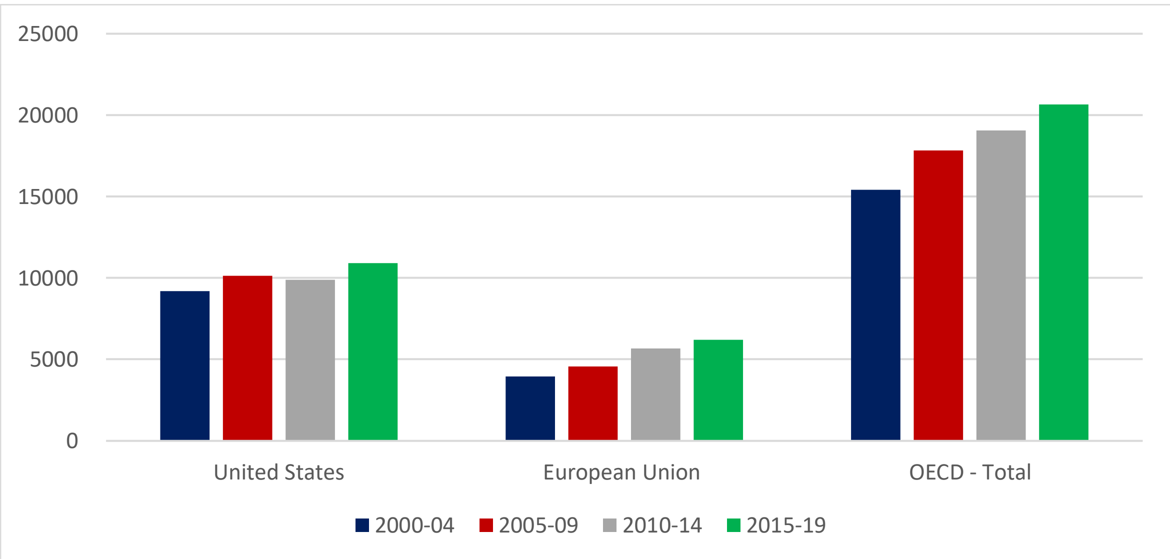

Figure 8. Monetary value of space GBARD for selected OECD countries (at current PPP$) over the period 2000-2019.

Figures 8 clearly shows that USA account for about half of total investment in space GBARD, with EU countries contributing for one quarter. The remaining share is invested by Canada, Japan, Korea, and other less committed economies (OECD, 2021).

Comparing space GBARD expressed as percentages of the whole civil GBARD (figure 6) with space GBARD expressed in monetary terms (Figure 7 and 8), it clearly emerges that the former is generally decreasing, while the latter is increasing (can be easily evinced by comparing the two "OECD – Total" parameters). The reason is two folded: first, according to OECD data, total civil GBARD has been growing at higher pace than space GBARD since 2000 (+133% versus +51%), resulting in a relatively decreasing percentage of the space component. Second, general macro-economic growth has determined increasing monetary value.

In order to provide a more comprehensive perspective on public investment's trend in space activities, aggregate monetary value of space GBARD for "OECD – Total" is presented in figure 9.

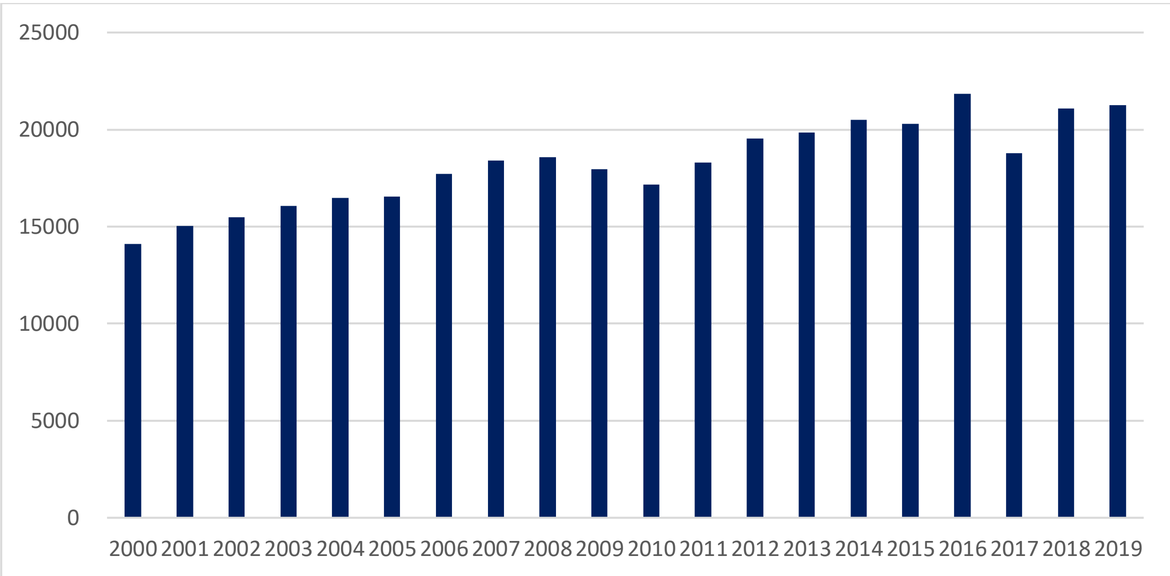

Figure 9. Monetary value of space GBARD for OECD – Total (at current PPP$) in detail over the period 2000-2019.

As previously observed, the monetary value of space GBARD for OECD – Total has been growing over the period 2000-2019, marking a solid growth of +51%. However, it is worthful to notice that after a sharp increase of about fifteen years, public annual investments have eventually plateaued at about $21 billions. These latest records somehow collide with rocketing performance of the space sector, which has experienced sustained and dramatic growth, especially during the last five years. Such contingent perspective may then suggest that public investors might have lost their function as prime engine of industry advancement, probably in favor of private agents. Despite this, public investments are still surely essential in ensuring a flourish and attractive economic environment.

5.5.2 Private investments

The role of public entities goes beyond the mere commitment of funds. In fact, besides directly investing in R&D and infrastructures, many governments have also tried to implement regulatory frameworks aiming at spurring private endeavors within different branches.

Specifically, commercial satellites telecommunications have been the forerunner for private and corporate venturing in space economy, with major companies in commercial geosynchronous satellite platforms such as Northrop Grumman, Lockheed Martin, Thales Alenia, Boeing, and Airbus, achieving outstanding performances over the years and sustaining commercialization process of the sector, progressively enhancing new business opportunities along the entire supply chain.

Some insights on increasing private commitment in the industry could be offered by aerospace industry's BERD[5]. However, the parameter presents limits due to several re-classifications occurred (OECD, 2021), and due to difficulties in properly tracing business enterprise investments, which may significantly vary on a yearly basis. All these issues result in partial data collection that compromises the validity of a hypothetical "OECD – Total" aggregate index (similar to the one used for space GBARD) and undermines a global and comprehensive analysis. Instead, focusing on institutional investors can provide a more grounded perspective, as such investors provide detailed reports and due diligence on their operations. Moreover, these agents generally focus on emerging projects and startups, providing a reliable proxy also for the state of entrepreneurship and innovation in the sector.

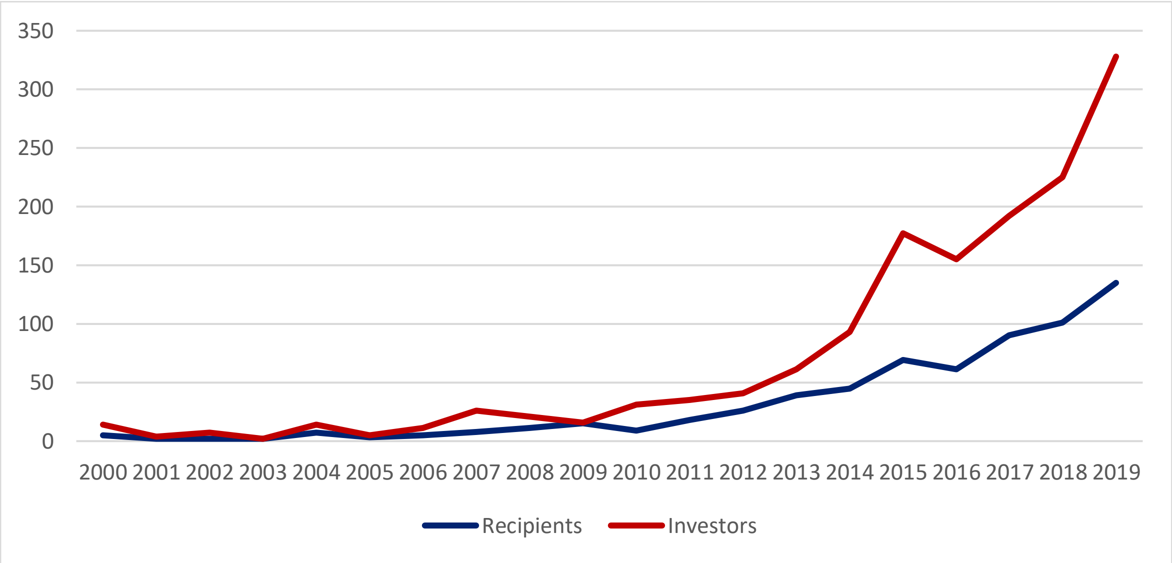

Figure 10. Number of space startups closing at least a financing round (recipients), and space investors on yearly basis since 2000.

[5] Business Enterprise Expenditure on R&D represents the component of Gross Domestic Expenditure on R&D which is attributable to the business enterprise sector.

Figure 10 represents the number of space startups closing at least a financing round, and the number of commitments from different investors on a yearly base. The graph presents a dramatic increase in the number of deals, especially since 2010 onwards, that certify growing interest in the sector. Besides commercialization, these trends are also driven by liberalization policies and by the increasing variety of COTS which are allowing several private newcos to enter the market and to compete for shares and niches, eventually attracting capitals (BRYCE Space and Technology, 2020).

Another point emerging is that the number of investors is considerably outpacing the number of financed startups. This latter evidence suggests that there are more investors than startups and that consequently, on average, each space newco is backed by several entities, probably to address conspicuous financial needs required even at early stages.

BRYCE identifies 967 different investors and an overall commitment of about $27 billions over the period 2000-2019 (but not all investors are disclosed, so the number might be higher). However, some countries are more able than others in generating and/or attracting such investments. BRYCE reports that in 2018 USA hosted almost half of space investors and more than half of the space startups globally financed (53 out of 100). In the same year, out the $3,5 billion globally invested, $500 million (about 14%) were raised by the American SpaceX, and $314 million (about 10%) by Chinese newcos involved at different levels of the satellite segment (OECD, 2019).

Nevertheless, an incremental number of newcos in accessing capitals, and the amount of funds committed by early-stage investors is considerably increasing. To furtherly analyze the composition of such investments, figure 11 represents main categories grouped per five years periods.

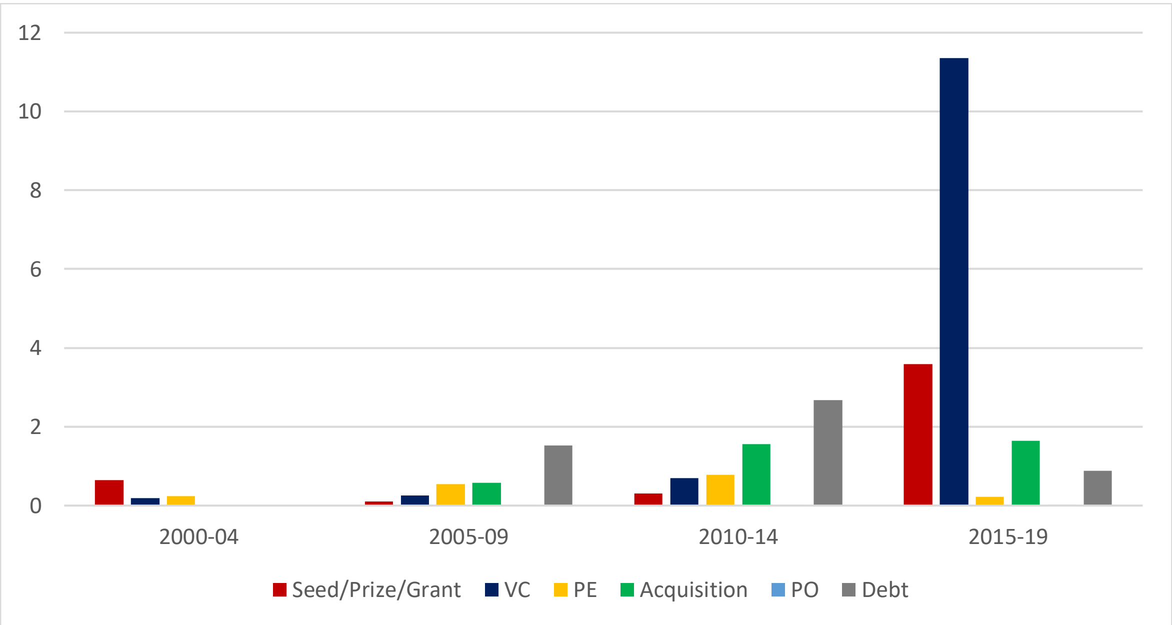

Figure 11. Investments in new space ventures per category (in billion USD) grouped per 5 years periods.

Focusing on space projects, about 50% of new ventures is backed by venture capitals, another quarter by business angels, and the remaining share is covered by debt, private equity, and corporate operations all together (BRYCE Space and Technology, 2020). Apart from being involved in about 75% of the transactions, VCs and BAs also provide the greatest share of funds to the sector, as it is evinced from the figure. In particular, the graph integrates and subsumes previous observations, as it clearly emerges that:

- Investments in space startups have boomed over the last period, characterizing a new market environment.
- Before the sharp increase in commitment from VCs (exponentially grown in 2015-19), debt represented newcos' main source of financing, probably refraining private endeavors and entrepreneurial initiatives.
- Seed/Prize/Grant have apparently followed VCs trend over the last fifteen years, even though at lower magnitude. From a theoretical standpoint this makes sense, as Seed/Prize/Grant require less capitals as they initially ignite endeavors and innovation that are then boosted by VCs.
- Corporate acquisitions have remained constant over the last decade but might considerably increase in the next future if some startups will develop relevant patents or gain significant market shares.
- Private equity consists in relevant shares for the periods 2005-09 and 2010-14, when overall equity investments where considerably lower and debt financing relatively high. Period 2015-2019 is instead characterized by a severe contraction, but PE investments are expected to increase as soon as startups will overcome early stages, reducing investment risk, and providing shorter profitability's horizons.
- No space newco has run an IPO. However, Virgin Galactic went public in 2019 through a reverse merger with the SPAC Social Capital Hedosophia Holdings. The transaction also brought about $450 million to the space company's account, but there was no direct sell of shares on the market. Similarly, Astra[6] became the first launch company to go public in July 2021 raising about $500 million, of which $300M from the merger with a SPAC, and $200M from BlackRock through PIPE[7] (Wall, space.com, 2021).

  For completeness, it is valuable to report that Virgin Galactic Inc. has eventually raised about $460 million through secondary offerings in august 2020 (Virgin Galactic, 2020).

[6] American launching space newco founded in 2016 by Chris Kemp and Dr. Adam London.
[7] Private Investment in Public Equity.

Current developmental level of the industry is clearly presented: most financed startups are still at the beginning of their business life cycle, which implies high risk, low or null profits, and high burn rate. These characteristics determine the limited number of M&A operations, the very low commitment from later stage investors such as private equity firms (looking for more established companies to invest in), and the great participation from Business Angels and Venture Capitals (seeking for very high returns). Apart from these records, interest in the sector is still growing and more institutional investors are approaching the industry, with some posing space investments at their core: BRYCE (2020) reports 37 venture capital firms investing in three or more startups in 2019, with some being particularly committed, such as Space Capital, Data Collective, and Khosla Ventures, respectively investing in nine, eight and seven different ventures.

However, a new trend has lately emerged in the space startup ecosystem, with notable companies and banks addressing increasing funds to corporate venture capital. Some examples are Boeing, Lockheed Martin, Goldman Sachs, and Softbank. These agents furtherly certify the appeal of the sector and the emergence of significant business opportunities that could generate profitable exits.

To provide a more contingent perspective, figure 12 reports detailed annual investments in startups over the period 2015-2019 per category of funding.

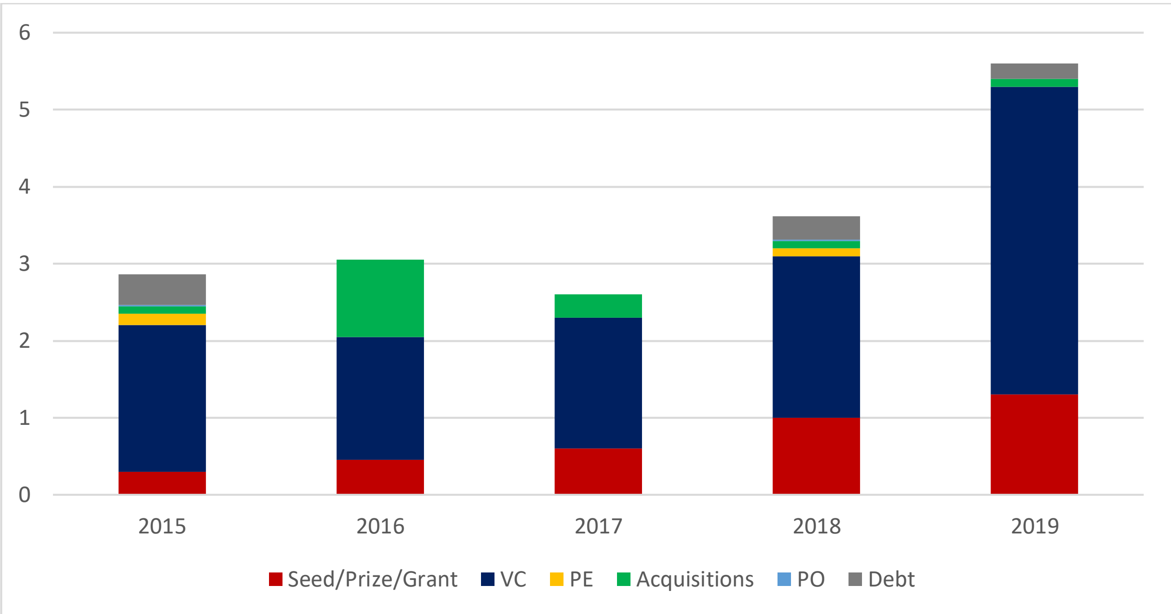

Figure 12. Yearly investments in new space ventures per category 2015-2019, in billion USD.

This graph helps furtherly understanding the evolution of investments' magnitude and composition over the last five years. Specifically, it reports constantly growing Seed/Prize/Grant, and solid participation of VCs, with booming commitment in 2019.

However, some extra investigation concerning capitals' distribution is required, as some companies have raised considerably more than the average. In particular:

- Blue Origin has implemented several self-capitalizations rounds through Jeff Bezos' funding for about $3,5 billions (most of which have been associated to seed financing over the period 2015-19), with biggest estimated tranche being a $1 billion commitment in 2019 (investments have not been officially disclosed).
- SpaceX and OneWeb have respectively raised about $3 billions and $3,4 billions through several VC rounds over the period 2015-19 (Crunchbase, 2021).

Therefore, these three companies have raised by themselves more than half of the funds addressed by investors during 2015-19, collecting about $9 billions out of the $17 billions globally committed.
As a matter of fact, such unequal distribution of funding among companies furtherly characterizes the competitive scenario, generating two macro dimensions: on the one hand few large new space ventures, usually backed by space billionaires or global investment companies such as Jeff Bezos, Elon Musk, Richard Branson, and Softbank (respectively committing in Blue Origin, SpaceX, Virgin Galactic and OneWeb), and on the other several minor new space ventures backed by smaller entities and raising relatively lower amount of funds.
To properly represent such juxtaposition, Figure 13 reports funds raised at VC level by SpaceX, OneWeb, and by other startups all together. Timeframe starts from 2009 because no significant VC round has been closed before ("zero" financing is therefore assumed). Seed/Prize/Grant are excluded from the analysis because Seeds are difficult to trace, as they might be undisclosed by parties, and cannot be properly divided across the years. Private Equity, Acquisitions, and Public Offerings are not included because they do not represent a relevant share of investments over the analyzed period.

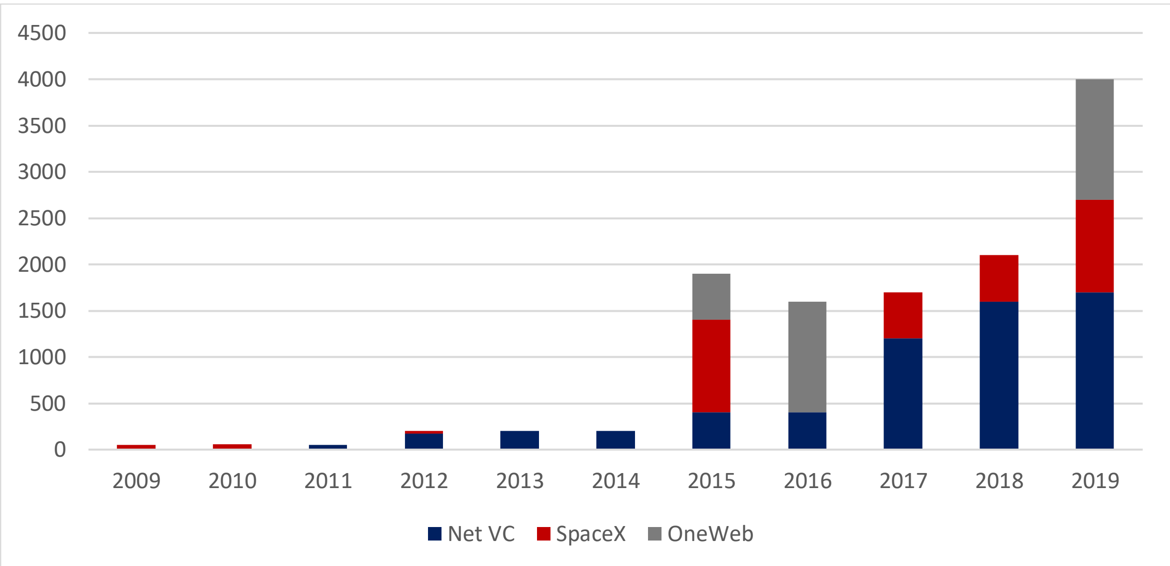

Figure 13. VC funds raised by SpaceX, OneWeb, and others (Net VC), in million USD.

Several valuable observations can be derived:

- Before 2011 there was no relevant VC investment in new space ventures, with funds raised by SpaceX representing almost the 100% of commitments.
- The period 2011-2014 was characterized by emerging VC investments in new space ventures, which globally approached $200 millions per year.
- 2015 registers booming investments, mainly driven by Google's $1 billion commitment in SpaceX and by SoftBank's $500 million investment in OneWeb. Net VC also registered a sharp growth, doubling with respect to previous year (from $200 million to $400 million).
- Despite SpaceX and OneWeb catalyzing about 50% of the funds committed to date, other startups' raisings (Net VC) have been increasing over the years at relevant rates, with turning points being 2015 (+100% with respect to 2014, reaching $400 million) and 2017 (+300% with respect to 2016, reaching $1200 million).
- Net VC eventually marked $1600 millions and $1700 millions in 2018 and 2019 respectively, defining new benchmarks.

Despite recent speed up of investments at Net VC level, a first glance to Figure 13 may suggest that SpaceX and OneWeb are draining most of the funds invested in the sector, leaving drops of financing to other startups. However, a more concerned analysis may lead to the hypothesis that the whole sector has been enhanced by these very companies, which have acted as forerunners, validating new solutions and drawing investors' attention onto new space business.
Indeed, a sharp growing trend clearly emerges when focusing on Net VC investments. In detail, figure 14 represents a polynomial trendline for the next periods.

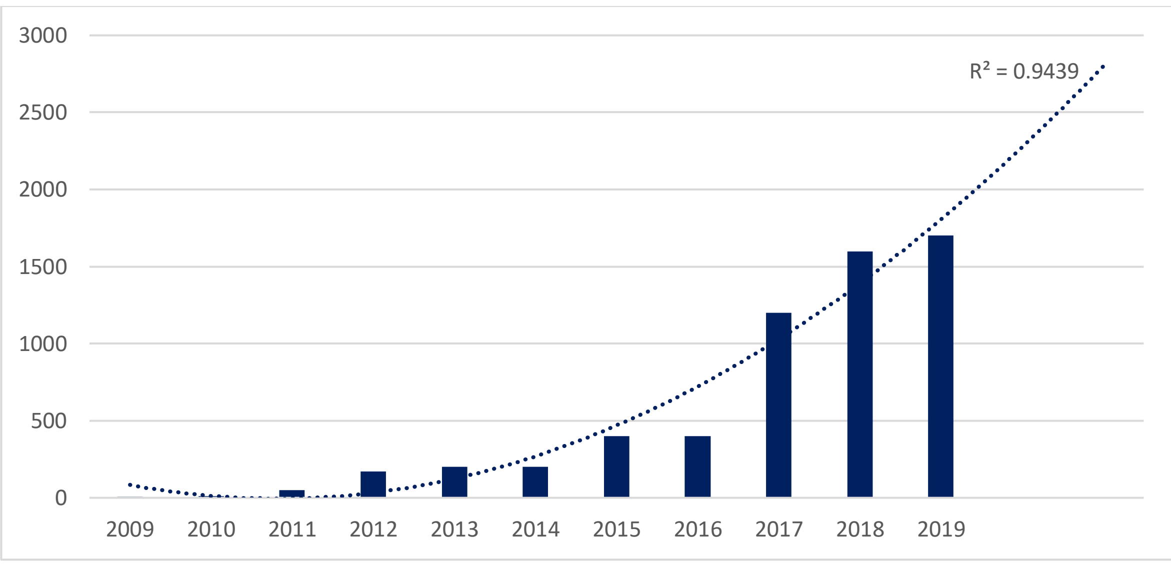

Figure 14. Net VC investments 2009-2019 in million USD, and trendline.

The value of R^2 suggests a good fit and allows grounded short-term predictions. Specifically, these estimates, suggest that Net VC would reach $2 billions within a couple of years.

Such increase in investments in minor space startups, together with the catalyzing effect played by SpaceX, OneWeb, and other newcos that will potentially rise over the next years, could furtherly enhance entrepreneurship in the new space, allowing an increasing pool of space startups to access capitals. This query will be furtherly discussed in the multivariable regression model, which offers a joint analysis of previously discussed parameters (industry's overall performance, public and private investments, major newcos raising), aiming at providing a model for predicting entrants, and at forecasting trends for the next decade.

5.6 Regression model

5.6.1 Objectives

The model aims at portraying how industry's macro-factors and investment patterns impact on the number of space startups accessing funds. It is built to incorporate elements previously discussed that effectively characterize the competitive scenario:

- Industry turnover.
- Level of public investments.
- Level of private investments.
- Funds raised by major newcos.

For consistency purposes, the model is built on actual data collected over the last 20 years by entities that make official disclosure and that provide full references on their materials, such as: The Space Foundation, nanosats.eu, crunchbase.com. Only piece of data obtained through workup is the one concerning industry turnover for the period 2000-2004, which has been derived from The Space Foundation's estimates on industry turnover for the period 2005-2019.

As anticipated in the methodology section, the regression analysis is characterized by limited observations due to the short horizon time, therefore it cannot provide full explanatory potential. However, it may be a valuable corollary model to get a clue on possibly increasing prominence of space startups over next few years.

5.6.2 Sample Description

Dependent Variable:

- FUNDED: Number of new space ventures accessing capital on a given year. It represents the number of new space ventures successfully closing at least a funding round, on a yearly basis. The variable portrays space startups' prominence in the industry and capital accessibility.

Explanatory Variables:

- REV: Revenues. It represents overall yearly revenues generated by the entire space industry in billions USD. It perfectly subsumes industry's performance.
- NVCINV: Net Venture Capital Investments. It represents the annual aggregate VC investment in emerging space companies in billion USD. This variable represents a proxy for private commitment in emerging minor space ventures and excludes funds raised by SpaceX and OneWeb, which belong instead to the category of major space newcos.
- SXOW: SpaceX's and OneWeb's funding. It stands for capitals raised by SpaceX and OneWeb in billions USD, on a yearly basis. This variable represents a proxy for private commitment in major space newcos.
- SGBARD: Space GBARD. It represents OECD total public investments in the space sector in billions USD, on a yearly basis. This variable is used as a proxy for public investments.

5.6.3 Sample Summary

Industry's main trends and factors have been extensively discussed in previous sections through comparative statistics and analysis, aiming at portraying the changing competitive environment. The Model directly generates from such discussion, and it is built on some of the variables already depicted. In detail, Table 1 provides a comprehensive perspective on such used variables. One element must be furtherly stressed out: sample's dimension does not allow to express data's full explanatory potential. Such issue is due to the fact that new space's competitive environment is relatively young and provides limited observations concerning space startups and emerging newcos, as well as a limited number of actors involved in collecting such observations, resulting in few datasets which have been built through similar methodologies. Such peculiarity is obviously a limit to the study, but also a source of value and of experimental beauty since it implies working at the frontier of events. Moreover, sample summary and its statistical analysis report sharp trends and clear paths, eventually grounding the willingness to accept a compromise between a lower statistical explanatory soundness of the model, and the valuable business insight it may provide.

	FUNDED	REV	NVCINV	SXOW	SGBARD
2000	5	128,7	0	0	14,1
2001	2	143,36	0	0	15,047
2002	2	158,0	0,059	0,061	15,474
2003	2	172,6	0	0	16,069
2004	7	187,26	0	0	16,493
2005	3	186,3	0	0,011	16,544

2006	5	220,2	0	0	17,713
2007	8	251,5	0,008	0,032	18,416
2008	11	257,0	0,051	0,029	18,565
2009	15	261,6	0,005	0,045	17,95
2010	9	276,5	0,02	0,05	17,165
2011	18	289,8	0,05	0	18,302
2012	26	304,3	0,17	0,03	19,533
2013	39	314,2	0,20	0	19,832
2014	45	330,0	0,20	0	20,497
2015	69	323,0	0,40	1,5	20,306
2016	61	329,0	0,40	1,2	21,848
2017	90	383,5	1,25	0,45	18,781
2018	101	414,8	1,15	0,95	21,087
2019	135	423,8	2,16	1,838	21,254

Table 1. Sample summary.

5.6.4 Descriptive Statistics

Besides FUNDED, which is expressed in unitary terms (i.e. the number of startups accessing capitals on a given year), all other variables are expressed in billions of USD. Descriptive statistics reported in Table 2 clearly presents variables characterized by high Standard Deviation and a wide Min/Max range. Such characteristic, together with previous comparative analysis, provides once again the picture of a highly changed (and still changing) environment, which has experienced sustained growth over the last two decades. Specifically, the number of funded startups presents very high S.D. with respect to mean (necessarily, as it went from 5 in 2000 to 135 in 2019). Generally, also independent variables present significant S.D., with only exception being SGBARD, which has indeed experienced a relatively milder growth over the last decades.

	FUNDED	REV	NVCINV	SXOW	SGBARD
Obs.	20	20	20	20	20
Mean	32,65	267,77	0,306	0,31	18,25
S.D.	38,96	87,6	0,568	0,574	2,192
Min	2	128,7	0	0	14,1
Max	135	423,80	2,162	1,84	21,85

Table 2. Descriptive statistics.

5.6.5 Correlation Analysis

Before diving into the linear regression model, correlation analysis may be useful to highlight how variables behave with respect to each other. Generally, high positive correlation appears.

	FUNDED	REV	NVCINV	SXOW	SGBARD
FUNDED	1				
REV	0,88154365	1			
NVCINV	0,94158627	0,76177905	1		
SXOW	0,85066733	0,65674601	0,77879878	1	
SGBARD	0,75924105	0,91041168	0,57117175	0,6546665	1

Table 3. Correlation analysis.

In particular, very high positive correlation results between NVCINV and FUNDED. Conceptually, some degree of causation may also be suspected, as a greater amount of funds invested at VC level on new ventures in ceteris paribus condition implies either a greater share of financing per startup (with the number of new space ventures being equal) or an increasing number of startups accessing funds. High correlation is registered also between FUNDED and REV, and between FUNDED and SXOW. Concerning the former case, one might hypothesize that increasing revenues could spur agents to invest in a wider portfolio of startups, while the latter may support the point that companies such as SpaceX and OneWeb might channel investors' interest onto new space economy, with the entire industry benefitting from extra funding. Lower yet still significant positive correlation appears between FUNDED and SGBARD. Here the point of causation that might be raised is straightforward and would concern the positive impact of public investments onto the number of new space ventures accessing funds. Very high positive correlation also appears between SGBARD and REV, which might be due once again to the igniting role of public investments in the space economy, while lowest correlation (yet still significant) appears between SGBARD and NVCINV (i.e. between public investments and the amount of funds invested in space startups) suggesting a limited impact of public investment onto space entrepreneurship.

5.6.6 Linear Regression Model 1

Analysis, hypothesis, and considerations ran so far, ground the interest for building up a regression model on previously described variables. Model 1 is a linear regression which presents FUNDED as dependent variable and REV, NVCINV, SXOW, SGBARD as explanatory ones. As already declared, the goal is to develop a significant model which might assess the impact of these variables onto the number of space startups successfully closing funding rounds, with the aim of deriving some short-term business insights concerning the changing scenario.

Regression Statistics	
Multiple R	0,98652297
R^2	0,97322757
Adjusted R^2	0,96608826
Standard Error	7,17513591
Observations	20

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	28072,3114	7018,07784	136,319479	1,3387E-11
Residual	15	772,238629	51,4825753		
Total	19	28844,55			

	Coefficient	*S.E.*	*t Stat*	*P-Value*	*Lower 95%*	*Upper 95%*
Intercetta	-29,860547	29,5912248	-1,0091014	0,32892779	-92,93275	33,2116556
REV	0,14584147	0,07510694	1,94178409	0,07118588	-0,0142452	0,30592813
NVCINV	34,1027523	7,56251927	4,50944336	0,00041541	17,9836241	50,2218806
SXOW	15,741743	5,81057141	2,70915575	0,01615928	3,35680318	28,1266828
SGBARD	0,44594912	2,56139434	0,17410405	0,86411168	-5,0135337	5,90543193

Regression Model 1

The determination coefficient of the model proves a good fit, as the adjusted R^2 is approximately 97%. Also, Significance F is considerably lower that 5%, proving model's soundness. However, SGBARD's individual P-value does not match the 5% requirement, and the variable appears as the least significant. As a matter of fact, previous comparative analysis has shown that aggregate public investment of OECD countries has remained relatively stable over the years, as opposed to the number of financed startups which has been constantly increasing, especially since 2010 onwards. Therefore, even though public investments have undoubtedly ignited initial private endeavors, they may cover a less relevant role in determining space startups' emergence.

Conceptually, it may also be the case that a minimal bulk level of public investments might be required to enhance private commitment, and therefore a significantly lower SGBARD may negatively affect other explanatory variables (which express private commitment and sector's overall performance), eventually affecting the dependent variable as well. However, such inference cannot be directly derived from this regression, as it goes furtherly beyond a linear regression analysis, but it may require further investigation in following research papers.

5.6.7 Linear Regression Model 2

Model 2 presents same independent variables reported in Model 1 except for SGBARD which has been excluded from the linear regression in the tentative of improving model's soundness and validity.

Regression Statistics	
Multiple R	0,98649555
R^2	0,97317347
Adjusted R^2	0,9681435
Standard Error	6,95431152
Observations	20

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regressione	3	28070,7508	9356,91694	193,474838	8,8475E-13
Residuo	16	773,79918	48,3624488		
Totale	19	28844,55			

	Coefficient	*S.E.*	*t Stat*	*P-Value*	*Lower 95%*	*Upper 95%*
Intercept	-24,855167	6,79250424	-3,6592052	0,00211715	-39,254632	-10,455701
REV	0,15787686	0,02846332	5,5466777	4,4233E-05	0,09753732	0,2182164
NVCINV	33,1896577	5,28085104	6,28490699	1,087E-05	21,9947535	44,3845618
SXOW	16,3537242	4,4844058	3,64679846	0,00217337	6,84720854	25,8602398

Regression Model 2

After the adjustment, determination coefficient remains about 97%, confirming the good fit of the model. Overall significance has improved, with F furtherly decreasing and remaining considerably below the 5% target. Moreover, all p-values of the explanatory variables are now fitting the required significance level of 5%, strengthening regression' soundness.

Specifically, the model predicts that:

- Despite being significant, REV coefficient is marginal with respect to other variables. In detail, every extra billion USD in industry turnover has only a limited impact on the number of financed startups, ceteris paribus.
- Each billion USD raised by SpaceX and OneWeb leads to about sixteen space startups accessing capitals, ceteris paribus.
- Every billion USD directly invested at VC level allows thirty-four new space ventures to close a funding round, ceteris paribus.

Hence, the model depicts a peculiar scenario, where funds accessibility is just loosely linked to overall industry performance, and instead it is severely bond to private investors' commitment and major newcos' funding records.

5.6.8 Final considerations on the model

Dynamics highlighted by the model suggest that investments in new space ventures are mainly driven by expectations on industry's short- and medium-term development rather than by actual (despite already extremely positive) results, emphasizing the importance of momentum and contingency for the sector.

In this scenario, funding performances from major newcos (SpaceX and OneWeb in the model, but potentially any other major space newco that will be able to raise consistent funds and gain the spotlight) appear crucial for creating and fueling investors' expectations. Not by chance, every and each achievement or failure from these iconic major newcos catalyze attention from the media and the public: Falcon 9's failures in returning procedures and following successful reentries, Virgin Galactic's initial delays and subsequent commercial manned spaceflight, Blue Origins' projects rejection by NASA and Jeff Bezos' launch in suborbital flight. All these events have shaped investors propension and expectations, indirectly allowing an exponential number of emerging companies to access funding and to prove their business models in the space sector.

Finally, as intuitively expected, also the amount of funds directly invested in minor space ventures at VC level positively influences the number of startups accessing capitals. However, most valuable insight here is that the model predicts that for every extra billion USD invested at VC level, only 34 startups will access funding, ceteris paribus. Such result suggests that the average round may consists of some tens of million USD, proving the industry as extremely capital intensive, even at early-stages.

In the end, after having analyzed main trends and path in the industry, Model 2 suggests that an increasing number of space startups will possibly access funding over the next periods and have the chance to furtherly develop and validate innovative technologies and business models. Such consideration strongly supports the hypothesis of a possibly dramatically changing competitive environment, with the industry that could experience an unprecedent level of innovation and, possibly, disruption.

5.7 Space newcos and contingency

As extensively discussed, new space economy basically presents two tiers of newcos: on the one hand major newcos which were born 10 to 15 years ago, and that are usually backed by visionary billionaires and/or by international entities (Google, Softbank, etc.); and an increasing number of minor startups (some of which have already raised significant funds though) which are competing to gain market shares (generally low-end or unserved).

Even if financial and contingent conditions vary significantly between and within these two tiers, none of such newcos can be said to be self-sufficient and already fully sustainable. This is because all these companies, even the major ones, are still validating and developing their core products, services, and business models, requiring huge capital to finance their activities. SpaceX is a clear example.

5.7.1 Focus on SpaceX's metrics and multiples

The company is primarily focused on manufacturing and launching rockets and spaceships. It has won several contracts from NASA, marked historical milestones for the industry, and it is probably the most established of the group. However, it has only recently achieved manned spaceflight (in mid-2020), and although being involved in several projects at the frontier of the sector, the sole source of revenue it can currently rely on is from launch services (for dispatching satellites into LEO, and for cargo transportation to the ISS).

Concerning Spacex' revenues, Figure 15 reports the number of successfully executed launches (excluding Starlink launches) on the left axis, and the average revenue per launch on the right axis (Trefis, 2021).

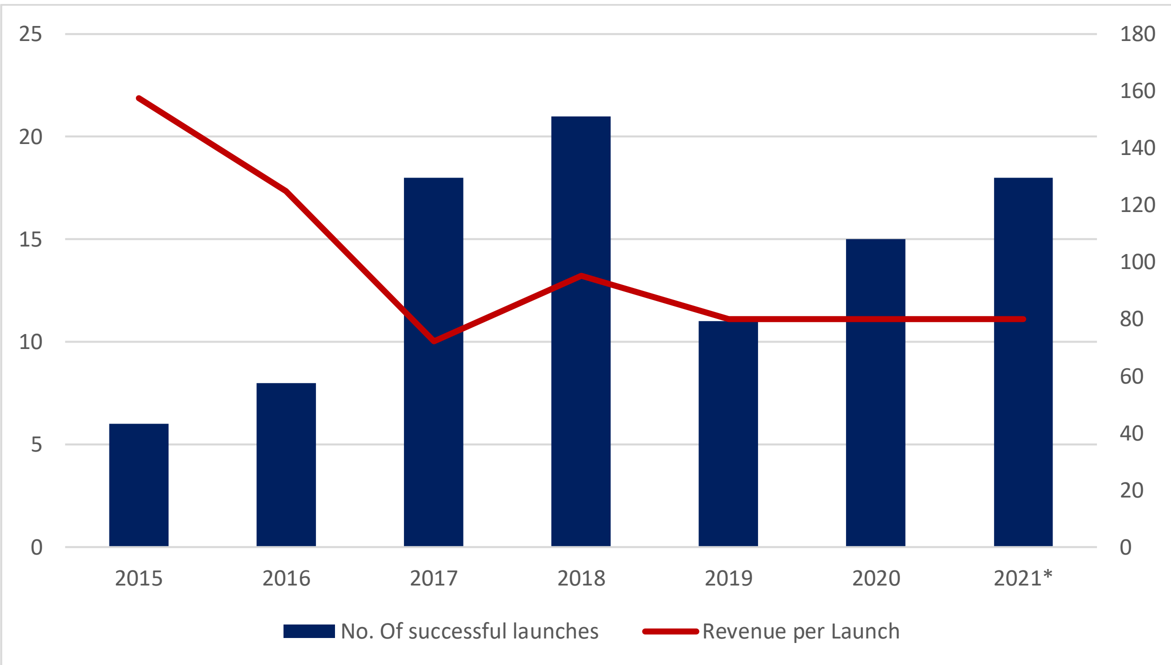

*Figure 15. SpaceX number of Successful Launches (unitary, left) and Revenue per Launch (million USD, right) over the period 2015-2021. *Forecasts by Trefis.*

Demand appears volatile: highest number of launches was reached in 2018 with 21 missions completed, while 2019 registered a sharp contraction, and 2020 is characterized by a bounce back. However, the company has closed several long-term contracts that will ensure greater predictability in demand path. These contracts negatively affected revenue per launch (second vertical axis) due to favorable conditions offered to recurring customers.

As of 2019, SpaceX charges about $60 million per Falcon 9 launch, and between $90 million to $150 million for Falcon Heavy launch. Also, SpaceX offers discounted launches for mission dispatching through rockets with reused components, affecting average revenues, but also improving operating efficiency (Trefis, 2021). In the end, revenue per launch went down from $157,5 million in 2015 to $80 millions in 2019, and apparently stabilized.

SpaceX’s Launch Revenues in billion USD over the period 2015-2021

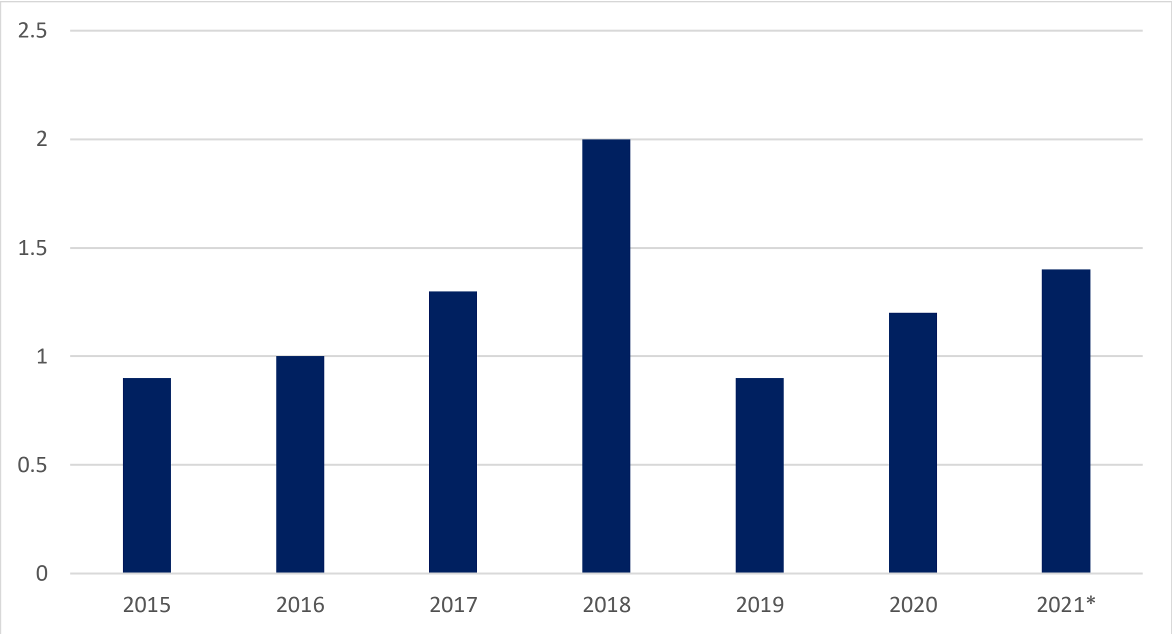

*Figure 16. SpaceX’s Launch Revenues in billion USD over the period 2015-2021. *Data forecasted by Trefis.*

Figure 16 reports overall launch revenues generated by SpaceX. Result in 2018 appears as an outlier because of both the relatively higher number of launches executed (previously reported in figure 15), and due to fuel temporary appreciation (Trefis, 2021). Besides this, SpaceX’s revenues have consistently remained about or above $1 billion since 2015. Moreover, in 2021 SpaceX will for the first time ever register “Other Revenues” item due to rollout of Starlink Services for about $150 million, resulting in an overall record of $1,55 billion in 2021 (Trefis, 2021).

However, such revenues cannot properly sustain SpaceX’s model and vision. The company has indeed resorted to several venture rounds raising more than $3 billions over the last five years. These financing have pushed valuation up to $76 billions in 2021 (Trefis, 2021).

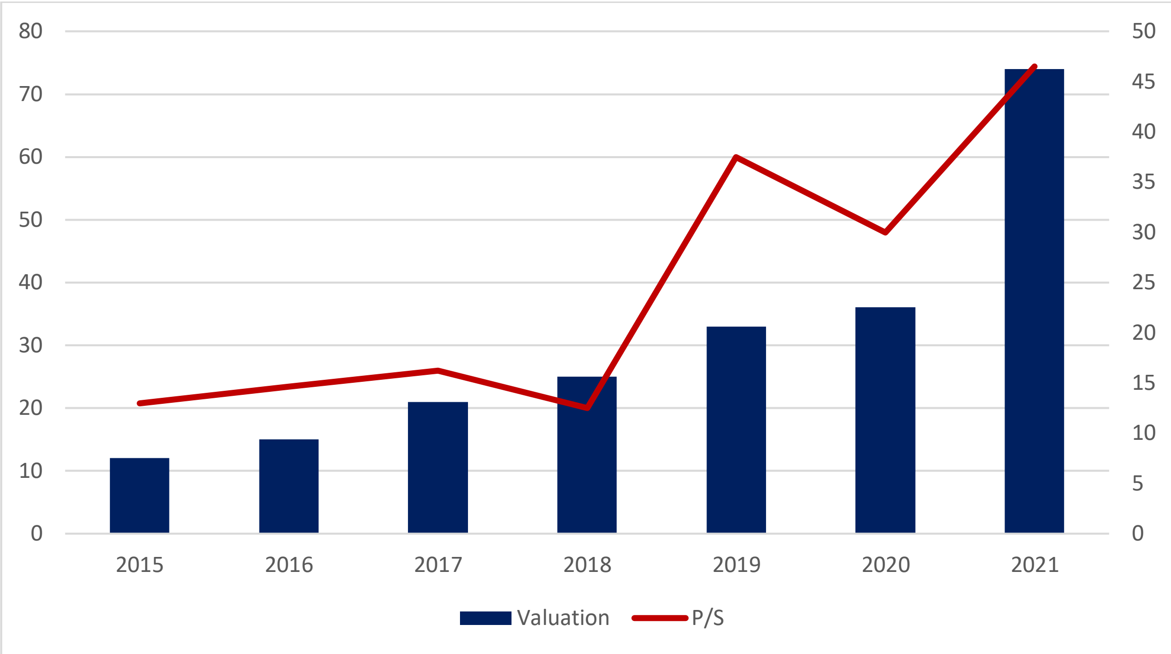

Figure 17. SpaceX Valuation (billion USD, left) and company's Price-to-Sales ratio (right) over the period 2015-2021.

Figure 17 reports company's valuation interpolated from funding-rounds (left). The trend clearly depicts a fast-growing company that has been able to catalyze financing for sustaining its promising projects, mainly Starlink service, which are expected to generate high returns within a short horizon time. Interpolated valuation, together with company's revenues, allows computing the Price-to-Sales multiple (right axis) which marked 46,5x for 2021. Such parameter dramatically exceeds multiples of incumbents such as The Boeing Company, Lockheed Martin Corporation, and Northrop Grumman Corporation that range from 1,5 to 2,5 (nasdaq, 2021), and clearly subsumes high expectations that investors build on SpaceX.

To sum up everything that has been stated so far, SpaceX can be reasonably considered as a successful space newco that could enhance creative destruction in the space industry over the next periods. It is probably also one of the most established from a technological perspective, possibly thanks to its reiterated partnerships with NASA that have been pivotal in the developmental process (even if some analysts suggest that such tight relationship might restrain SpaceX's future commercialization because of national security purposes). However, its peculiar financial and business contingency, together with the huge amount of funds that have been recently raised to support the development of core operations, restrain SpaceX within the boundaries of those companies that besides being fast scaling and highly innovative are not self-sustainable yet.

5.7.2 Considerations on the changing competitive scenario

SpaceX is just one of emerging space ventures that have already reached a valuation of several billion USD. However, apart from Virgin Galactic and very few other newcos (i.e. Astra) no one has gone public so far.

Investors and analysts firmly believe that these companies will mark astonishing performances over next periods. Therefore, remaining fully private allows to both shield company against speculation (as these newcos are currently burning considerable amounts of cash generating low or null profits) and to maximize capital gain (as their value is expected to grow dramatically over the next decade). Promising perspectives also generate excitement in the industry, attracting more entrants that wish to compete for both market shares and capitals. However, besides growing trends and widespread dynamism, a second and wiser glance would raise some concerns:

1) The average long-term investment horizon of the industry, in conjuncture with emerging lean (non-proven) business models, may end up in several newcos raising considerable funds and eventually going belly-up before even servicing the first customer.
2) The increasing number of startups entering crowded sectors (such as RLVs) may require newcos to merge or at least to partner up for consolidating activities and operations, in order to avoid the creation of a mosaic of cash-burning and underperforming companies.
3) Enthusiasm surrounding space activities may grow faster than actual commercialization and technological development, eventually leading to economic bubbles.

6 New Space Economy

All the evidence reported and analyzed through previous chapter portrays an evolving competitive scenario which is generally defined as “New Space”. Such new stage of space economy is characterized by emerging business opportunities, strengthened commercialization, and lower barriers for entrants, eventually resulting in increased competition and potentially new means for innovative solutions at all levels of the supply chain.

6.1 Emerging sectors

Space industry has been generally declined in three major fields: satellites manufacturing, support ground equipment, and the launch segment. However, major newcos and other startups are dramatically investing in R&D, enhancing innovation at different market levels. This process untaps market potential and generates new segments.

New Space businesses are often interconnected and may belong to different levels of the very same supply chain. In general, emerging verticals can be grouped within a limited number of macro areas, each of which is usually characterized by one or few leading major newcos servicing high-end and mass segments, and by several minor startups that tackle low-end verticals aiming validating their business models and technology to possibly enhance disruption through the whole sector.

6.1.1 Reusable Launch Vehicles

Reusable Launch Vehicles (RLV technology) are conceived with the purpose of lessening launching costs, making orbital and sub-orbital missions cheaper and more accessible. One of the most successful programs was the Falcon 9, jointly implemented by SpaceX and NASA: the two agents respectively disbursed about $450mln and $400mln to fund rocket and capsule development. The first working prototype was realized within 5 years and launched in 2010. According to NASA, a similar but fully internally developed program would have required about $4 billion (NASA Associate Deputy Administrator for Policy, 2011). In general, every major space company has currently developed its own RLVs (i.e. Blue Origin realized New Shepard, Virgin Galactic the SpaceShipTwo, etc.). Nevertheless, launching costs still account for the greater part of space missions’ budget, and the majority of emerging space startups is still committed in R&D for RLV’s optimization and improvements. Main areas of innovation currently concern design, dimension and functionalities of rockets and cargo capsules, fuel’s consumption optimization, reusability of components.

RLV directly impacts several space verticals such as launching satellites, manned and unmanned spaceflights, refurnishing missions to ISS, point-to-point flights, and in-orbit testing.

6.1.2 Satellites manufacturing, servicing, and applications

Modern ICT (Information and Communication Technologies) and major satellites' applications currently require full transition from independent orbiting units to constellations of synchronized satellites. The new paradigm ensures full coverage of the globe and greater data collection and transmission.

One of the applications that recently gained the spotlight is satellites for broadband internet access. Such promising emergent segment has been promptly tackled by OneWeb and SpaceX (through the Starlink project), resulting in several billions USD already committed. However, there are many companies that are now approaching constellation of orbiting satellites for other applications such as earth observation, environmental management, navigation systems, etc. The switch from single units to more complex systems has generated an entirely new supply chain that grew onto traditional satellites industry, with several newcos entering the market and offering innovative solutions for manufacturing, servicing, and implementing such constellations, potentially generating disruption within architectural innovation.

6.1.3 Space tourism

Space tourism aims at sending civilians into space through commercial spaceflights for entertainment purpose. This segment has easily captured western public attention, with major newcos collecting several billion USD of investments. One of the most committed newcos is Virgin Galactic, which already boasts more than 600 reservations from 60 different countries, resulting in approximately $80 million collected and over $120 million of potential revenues (Virgin Galactic, 2020).

Space tourism's era has officially started in July 2021, when the very same Virgin Galactic and Blue Origin successfully executed first manned touristic launches, sending their founders (i.e. Richard Brandon and Jeff Bezos respectively) into orbit, and allowing them to experience in-space zero gravity. Next frontiers might reasonably be beyond-orbit spatial journeys, and, potentially, commercial moon landings.

6.1.4 Space exploration

Space exploration includes manned and unmanned operations, and it is by far the most fascinating and capitally intensive field. SpaceX and Blue Origin have proven as the most committed private companies in the sector, collaborating with international agencies and implementing a contingent roadmap towards several ambitious goals such as sending man to Mars, and developing permanent human settlements onto Moon's surface. Nasa itself is concretely investing its Artemis project to ignite lunar economy (NASA, 2020). In general, space exploration is generating an incredibly extended supply chain, with several newcos focusing onto emerging niches and on highly specialized productions and services, and might be pivotal in furtherly untapping new market segments (i.e. satellite market for lunar and Martian orbits).

6.1.5 Asteroid and planet mining

Asteroid and planet mining concern the extraction and exploitation of raw materials from asteroids and other minor planets. This branch of space exploration has gained the spotlight few years ago and was declined into two subbranches: on the one hand extraction and exploitation on source planet or satellite (Moon, Mars) for building and providing for human settlements; on the other the extraction for on-Earth usage. Whereas the former subbranch sounds at least economically plausible (transportation of raw materials implies high cargo-space occupation and considerable mass to be launched, validating projects aiming at ensuring on-site extraction and usage), the latter results quite unrealistic, as opportunity cost of raw material's extraction and through-space transportation is huge. Not by chance, several companies have been established with the purpose of enhancing asteroid mining[8], with Planetary Resources and Deep Space Industry being the most known, but none of such managed to deliver tangible results, and many of them were eventually shut off.

In the end, unless traditional mineral procurement incurs severe crisis, or industry's development is spurred through massive incentives, it's unlikely that mining for on-earth usage will generate business opportunities in forthcoming years, while on-site exploitation may result in some interesting projects. Despite this, no company is tangibly investing or committing in this sector at the moment (Abrahamian, 2019).

6.2 Manufacturing and launching satellites in the new space

As extensively discussed in the previous chapter, besides directly investing in R&D and infrastructures, many governments have also tried to implement regulatory frameworks aiming at spurring private endeavors within different branches.

Most of public effort has historically been addressed to commercial satellites' development, which were (and still are) the main source of revenues for the industry, with big corporations leveraging public assets and infrastructures to run their own businesses and operations. New Space economy has itself been spurred by investments in manufacturing, launching, and servicing payloads, posing once again the whole segment at its core.

Nevertheless, OECD affirms that sending satellites to orbit in 2010 was still an operation that only few countries could perform: out of 50 countries with orbiting payloads in 2008-2010, only 10 possessed launching technology, and, among those, only US, Russian Federation, China, Japan, and

[8] Asteroid mining generally implies on-earth usage, whereas planet mining may imply both extraction for on-earth and on-site usage.

ESA had the rockets to reach the geostationary arc (where main commercial telecommunications and meteorological satellites are placed). Besides low infrastructural and technological readiness, main issue still concerned accessibility due to pricing. However, over the last decade, more than 20 countries have developed space programs, with 82 having at least an operating satellite orbiting in 2018. Africa too is experiencing increased space activities, with 8 countries exploiting their own orbiting payloads, mainly for environmental management and telecommunications purposes.

Figure 18 shows evolution of overall satellite industry's annual revenues with respect to the whole space sector. Space economy overall turnover is reported since 2000, leveraging estimates previously obtained for the period 2000-2004. Data of the satellites sector are taken from Satellite Industry Association.

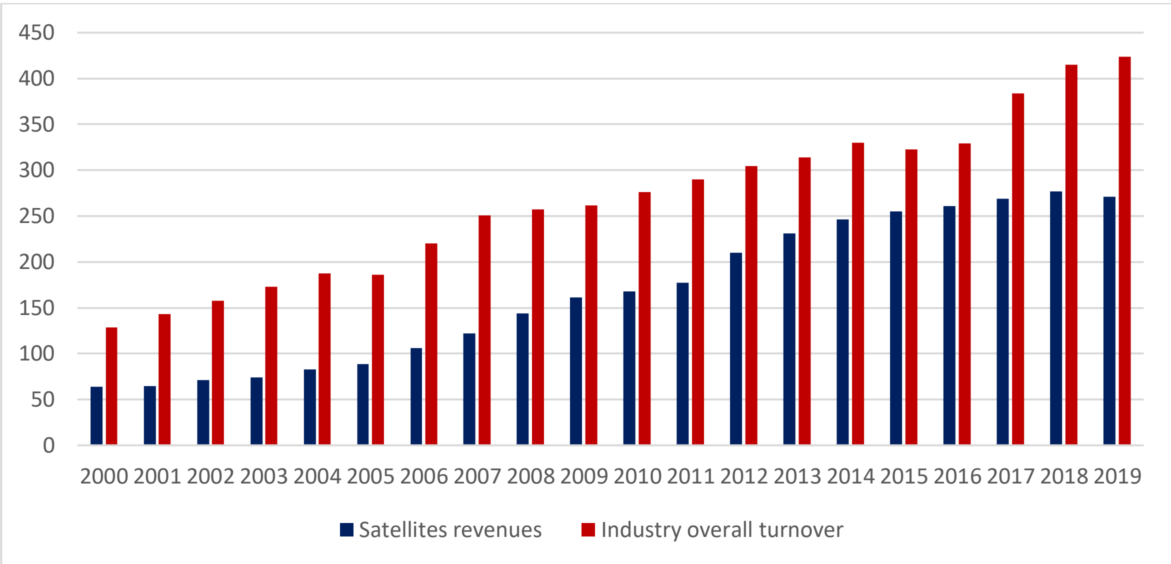

Figure 18. Satellite industry's annual revenues with respect to space economy's overall turnover (2000-2019).

The graph clearly presents sector's relevance within the industry. In general, commercial satellites sector has experienced increasing growth rate over the years 2000-2012, while the latest period is characterized by a progressive slowdown, resulting in 2019 being the first record with a contraction. Specifically:

1. Since 2000 to 2003, satellites sector has experienced poor growth rate with respect to the overall industry, which marked instead relevant performances.
2. During the period 2004-2014 satellites have driven and outperformed the expansion of the whole space sector, gaining relevance within the industry.
3. During the period 2015-2016 satellites industry's performance stabilizes, while the whole space economy experiences a slight contraction.

4. Since 2017, satellites' performances stabilizes while overall industry scales up. Such trend might be due to both a cyclical levelling of the satellite segment after years of sustained growth (determining plateauing performances), and to the increasing economic value of emerging new space markets (some of which might have directly branched out from the very satellites industry) determining the upswing of space economy.

To provide a more contingent perspective on the contribution of satellites segment with respect to others, figures 19 is presented.

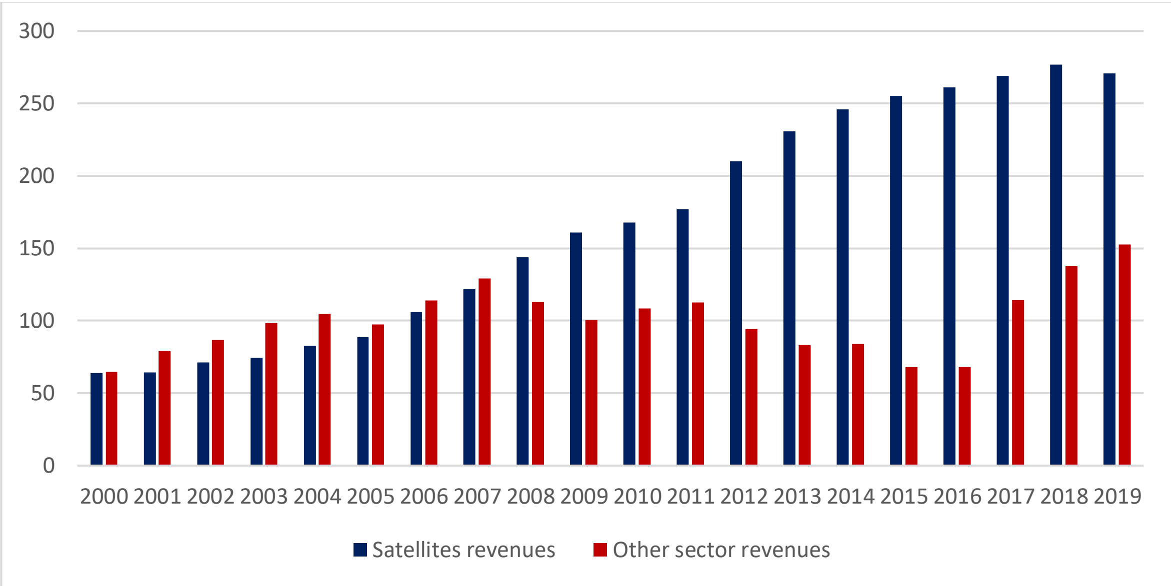

Figure 19. Satellite industry's turnover with respect to other sectors' aggregate revenues (2000-2019).

Figure 19 clearly shows that the satellite sector represented about half of the space industry over the period 2000-2007, and its greater share since 2008 onward (up to generating about 80% of space economy's turnover in 2015-2016). Besides latest slowdown and slight contraction in 2019, the satellites segment is expected to growth flourish over the next few years, mainly pushed by technological development and by investments committed by new space companies in emerging satellites business (such as from OneWeb and SpaceX in broadband internet access), determining a revamp of the segment (Morgan Stanley, 2020).

Focusing on current market dimensions, Figure 20 reports the composition of revenues generated by the whole satellites industry in 2019. Data are taken from SIA[9].

[9] Satellites Industry Association. Entity that gathers and works up data concerning the whole satellites sector.

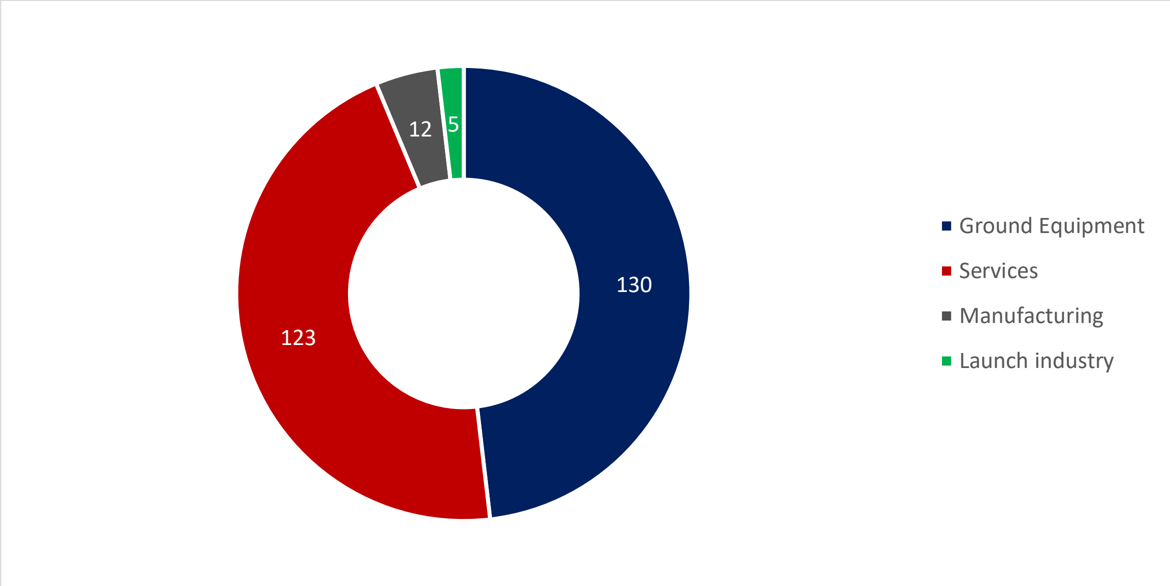

Figure 20. Revenues of the satellite industry in 2019 divided per component (in billion USD).

It clearly emerges that services and ground equipment represent most of sector's revenues, accounting for about $253 billions of the $271 billions generated (94% of the whole pie). The former includes most of space technology's downstream applications for commercial purposes, telecommunications, remote sensing (for meteorology, agriculture, earth science), and national security. The latter includes both consumer equipment and network equipment such as GNSS[10], Sat TV, Getaways, etc, to allow mentioned applications working.

Launching and manufacturing account for $5 billions and $12 billions respectively, representing the remaining 6% of the industry. Despite this, these two segments have been characterized by several investment opportunities since 2012 onwards. Space Capital reports 556 financing rounds closed by innovative companies operating in these very two segments, respectively 300 in launching and 256 in manufacturing (Space Capital, 2021). China even registered about $190 million invested in the launch segment in 2019, representing about 60% of overall commitment in Chinese new space ventures (BRYCE Space and Technology, 2020). These numbers globally certify a dynamic scenario with several investment opportunities, and a fertile environment for private endeavors.

Moreover, the broad range of services offered, and the high degree of sophistication and specialization reached by the industry, finally resulted in a wide portfolio of solutions provided: products and services vary significantly in the technology used and in costs, depending on the typology of satellites manufactured, on implementable applications, on the launcher needed, and on the orbit required.

[10] Global Navigation Satellite System.

Despite such diversification, reduction in satellites' cost and dimension has been a widely shared trend through the last decade: average commercial payloads have passed from several thousands of kilograms to some hundreds, with increasing dispatchment of minisatellites (100kg-500kg), eventually spurring R&D for compact launchers. Electron rocket by RocketLab[11] (one of the smallest operating launchers, with a height of 18 meters), was indeed conceived with the purpose of servicing small commercial satellite market, launching about 200 kg of maximum payload to a 500 km SSO, or about 300 kg to generic LEO. It serves since 2018 starting from $5,7 million per ride (Etherington, techcrunch.com, 2020).

Considering that the Falcon 9 from SpaceX (70 meters tall) provides rides for about $60 million (which drop to $50 million for a reused vehicle) launching 8.000 kg into GTO, and about 22.800 kg into LEO, Electron has considerably lowered the threshold for accessing space, becoming a leader in the segment.

Virgin Galactic is targeting small launches as well. The company has established a spin-off in 2017, Virgin Orbit, to develop its own solutions for compact payloads. LauncherOne is a 21 meters tall rocket that follows air launch procedure (it is carried to upper atmosphere by "cosmic girl", a modified Boeing 747, and released above the Pacific Ocean), dispatching up to 300 kg into 500 km SSO for about $12 million per ride. LaucherOne successfully executed test missions in January 2021, and it is about to be officially commercialized, furtherly enhancing space accessibility (Virgin Orbit, 2021).

However, despite new solutions offered, costs and dimensions remain relevant and still imply organizing rideshares[12] for operators willing to dispatch microsatellites (10-100 kg) or smaller payloads, as well as servicing through conventional spaceports' infrastructures, eventually resulting in long waiting lists (from 9 months up to a couple of years) and decreased operability. All these issues cut off a significant share of potential operators (i.e. customers) which might be interested in cheaper and less committing launches for academic purposes, basic earth observation, in-orbit testing, and other applications.

Concerning small launches, inefficiencies due to cost, operational, and dimensional unfitting, have been furtherly exacerbated by the recent rise of U-class spacecrafts, commonly known as CubeSats.

CubeSats are miniaturized satellites for space research that consist of multiple cubic modules of 10x10x10 cm, with a mass of about 1,33 kg per unit (nanosatellite). They are modular in the sense

[11] An American startup founded in 2006 and focused on developing launchers and providing launching services.

[12] Several operators agreeing to jointly launch payloads for optimizing available space and sharing the price of dispatching into orbit.

that several units can be combined to form bigger payloads (3U, 6U, 8U, etc.) allowing scalability and increased functionalities. Since CubeSats' electronics and structure is generally realized through COTS components, they were initially designed for academic purposes to let students experiment on cheap and maneuverable devices. However, progress in miniaturization procedures and technological development allowed to build and eventually dispatch CubeSats with improving functionalities, increasing operators' demand.

U-modules used to be dispatched as secondary payloads in rideshare to occupy the small empty space remaining after major satellites, but their increasing prominence has generated a new market segment requiring less cargo space, lower costs, and faster execution.

First launch happened in 2003, but only 75 modules had entered orbit by 2012. To date, more than 1500 CubeSats have been launched into LEO, most of which during the last few years (nanosats.eu, 2021).

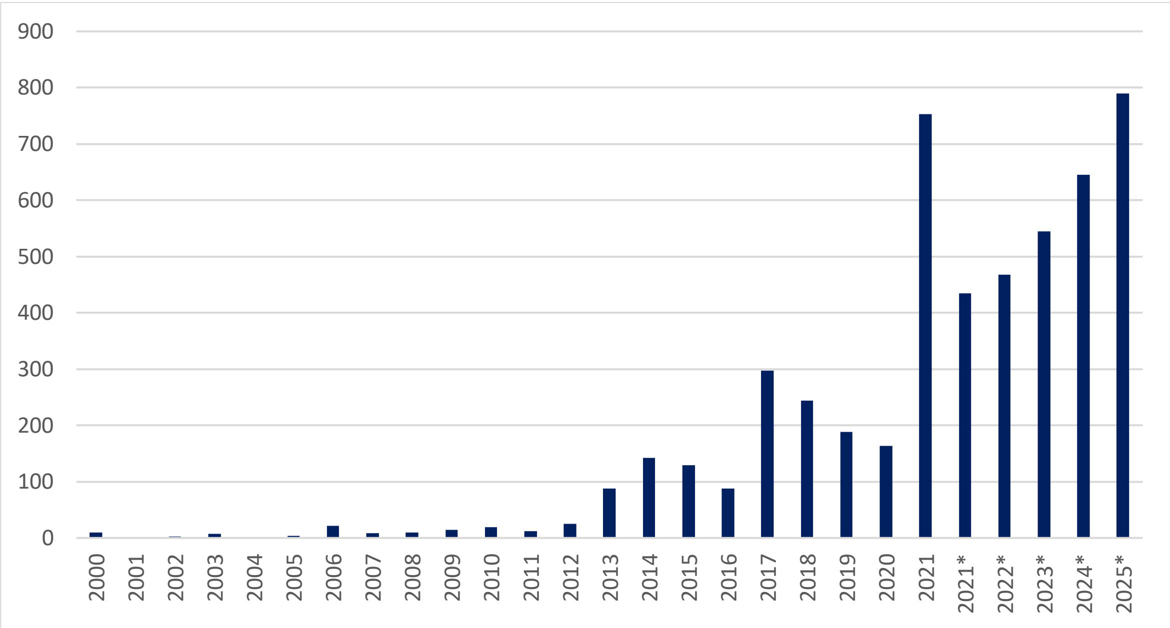

Figure 21. Small satellite launches executed or scheduled over the period 2000-2021 and estimates for 2021-2025*.*

Figure 21 reports the number of picosats (0,1-1 kg), generic nanosats (1-10 kg), and CubeSat (usually considered as nanosats, but final weight depends on the number of modules) dispatched since 2000. Starred years are predictions made in January 2020 by nanosats.eu[13]. Year 2021 includes both scheduled launches and those already executed.

In general, the graph clearly shows that small satellites are gaining progressive relevance since 2013, even if at discontinuous rate. Specifically, four main phases might be identified:

[13] Nanosats.eu by Eric Kulu is a private entity collecting and elaborating data on CubeSat and other small satellites.

- A “too green” period (2000-2012) with nanosats and picosats mainly used as demo products and almost no launch executed, possibly because of relatively high launching costs and low functionalities.
- A “first interest period” (2013-2016) characterized by about a hundred of yearly launches.
- An “illusion and disillusion period” (2017-2020), with the number of launches in 2017 suddenly remarking a 200% increase on previous year, and then a progressive and constant contraction, with 2020 that only registered about 150 launches, going back to 2014’s levels.
- A “Revamp phase”, with 2021 considerably outperforming the 434 launches predicted in January’s 2020 and recording 753 nano/picosatellites dispatched (about +360% on 2020).

In January 2020, Nanosats.eu also forecasted about 460 launches for 2022. However, 223 have already been scheduled, preluding a second year in a row above expectations. The plausible overperformance, if actualized, may considerably set new benchmarks for the next future, certifying increased market relevance of nano and picosatellites.

Going more in depth with the analysis and focusing on different typologies of small satellites dispatched to date, an explicative scenario is presented by the following graph.

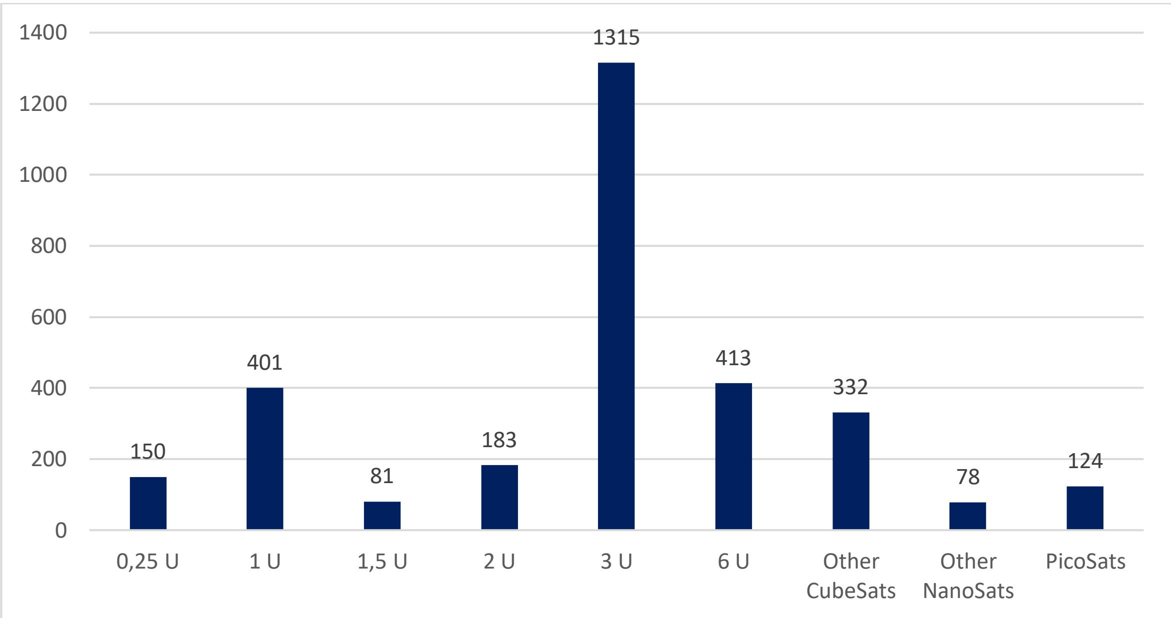

Figure 22. Number of CubeSats, nanosatellites, and picosatellites dispatched since 1998.

In detail, figure 22 reports the sum of to-date small satellites dispatched and of those already scheduled (3077 in total). It clearly emerges that CubeSats are involved in most of small launches, accounting for almost 93% of the total. Among U-modules, clear prominence of 3U also appears, as they represent about 43% of total launches, and about 46% of U-modules dispatched (1315 out of 2875). It is also valuable to highlight that 1U modules only account for 14% of CubeSats launched to date. This datum emphasizes the value that modularity and scalability had in determining CubeSats' success against other nanosats (which only account for 2,5% of the launches to date). Focusing on latest records, figure 23 provides a contingent perspective on 2021 launches.

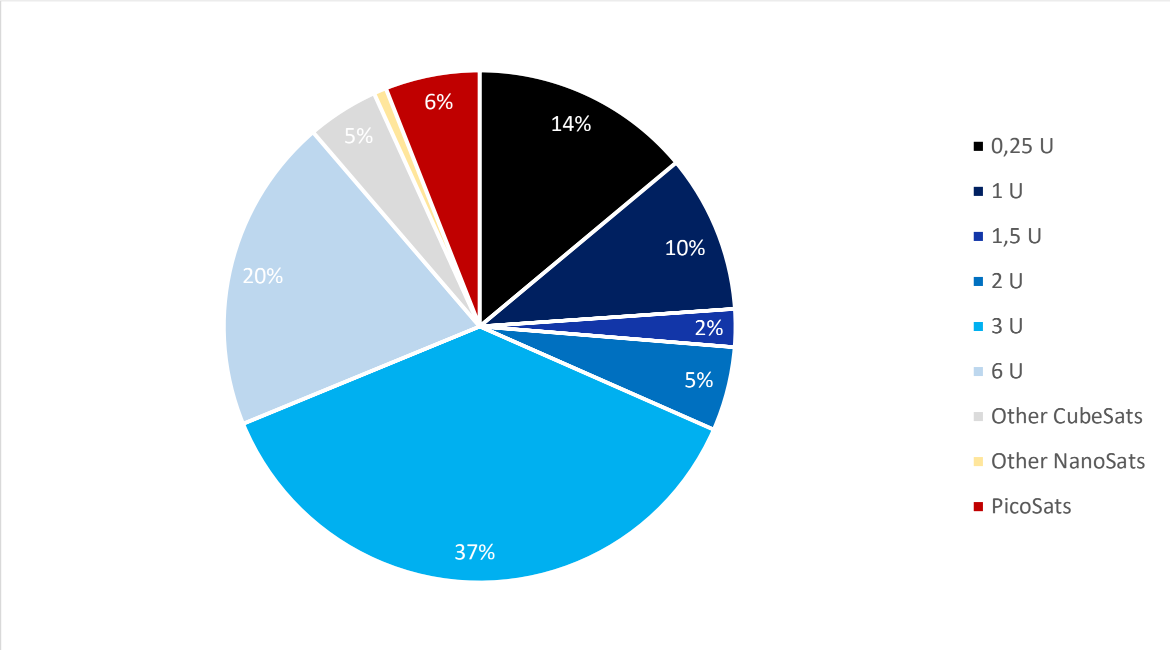

Figure 23. Small payloads dispatched in 2021 per category.

U-shaped spacecrafts account for 702 out of 753 small payloads dispatched in 2021, comprehensively representing more than 93% of the total. Moreover, Figure 23 introduces remarkable evidence that furtherly stresses out how CubeSats are becoming an industrial standard for the small satellite sector: whereas to-date records report general picosats and fractional U-modules (i.e. modules smaller than 1U) to account for about 4% and 5% respectively (i.e. almost comparable share), Figure 23 portrays a sharp rise of 0,25U modules, that represent about 14% of all launches in 2021 (105 launches), whereas general picosats dispatched where only 6% (45 launches) of the total. This means that even when dealing with 0,1-1 kg payloads, operators prefer working with a fractional U-spacecraft rather than with other typologies of generic picosats. Such evidence highlights how CubeSat are potentially setting an industrial standard not only at nano level, but also in the picosats vertical, possibly driving out most of other typologies of small satellites dispatched.

7 Sidereus and disruptive innovation

The increasing prominence of smaller payloads, CubeSats particularly, is aggregating a growing number of operators requiring compact launchers that could service at significantly lower cost and with greater efficiency. This emerging demand has spurred R&D and investments aimed at developing an alternative solution to rideshares in traditional vehicles, and to furtherly lower the thresholds for accessing space. These factors make the nanosatellites' launching segment extremely valuable for presenting a practical business case concerning how newcos are trying to tackle emerging business opportunities. In particular, the case of Sidereus Space Dynamics will be presented.

The company was founded in Italy in 2019 with the mission of democratizing access to the orbit by reducing space shipping costs, and with the vision of allowing private entities (universities, space companies) to possess their own launch vehicle for commercial and research proposes. Such ambitious goal is pursued through the development of a small (less than 4 meters tall), accessible, and reusable launch vehicle that could be operated by few people thanks to technological miniaturization, Commercial-Off-The-Shelf components, and innovative technologies.

Table 4 represents Sidereus' Business Model Canvas and provides a sharp glance on company's building blocks. Specifically, the framework allows to easily identify which is company's value proposition, and through which means it aims at actualizing it.

<table>
<tr><td colspan="2" rowspan="2">Key Partners
Providers of sub-systems, spaceports</td><td colspan="2">Key Activities
R&D</td><td colspan="2" rowspan="2">Value Proposition
Democratizing space launches through fast execution, reliability, accessibility</td><td colspan="2">Customer Rel.
Ad-hoc support in standard and customized missions</td><td colspan="2" rowspan="2">Customer Segment
CubeSats Operators (i.e. universities, private companies, research labs)</td></tr>
<tr><td colspan="2">Key resources
R&D team, capital, COTS, operating permissions</td><td colspan="2">Channels
Proprietary website, vertical networks, partnerships</td></tr>
<tr><td colspan="5">Cost Structure
Currently cost-driven (concerning procurement of COTS and other components, fuel, expendables)</td><td colspan="5">Revenue Streams
Possibly usage fee (standard pricing for launches and rideshares, customized pricing for advanced missions) but other streams might be implemented</td></tr>
</table>

Table 4. Sidereus' Business Model Canvas

However, before discussing in detail company's characteristics and strategic approach, it is valuable to portray the competitive scenario Sidereus belongs to.

As previously reported, one of the most compact launchers currently used for small satellites' dispatchment is Electron by RocketLab (18 meters tall and 200 kg of cargo space). However, the increasing prominence of nano and picosatellites is attracting newcos which aim to gain their own spot in compact RLVs segment through innovative technologies and more efficient solutions. Some of the most committed are: Isar Aerospace (GER), RFA – Rocket Factory (GER), HyImpulse (GER), Astra (USA), Phantom Aerospace (USA), Launcher (USA), Skyrora (UK).

	Astra	**HyImpulse**	**Isar Aerospace**	**Launcher**
Nationality	USA	Germany	Germany	USA
Founded Date	2016	2018	2018	2017
Total funding	$300M	$3M	$182,6M	$14,9M
Latest Round	Post-IPO Equity	Grant	Series B	Series A
Vehicle	Rocket 3	Spectrum	Small Launcher	Launcher Light
Payload to LEO	150 Kg	500 Kg	500 Kg	150 Kg
Stages	2	2	3	3
Length	12 m	27 m	27 m	15 m
Testing launch	2018	Early 2022	2022	2024
Propellant	RP – 1 / LOX	Hybrid engine	RP – 1 / LOX	RP – 1 / LOX

Table 5. Lately founded newcos developing RLVs for small satellites launch

	Phantom Space	**Rocket Factory**	**Skyrora**	**Sidereus**
Nationality	USA	Germany	UK	Italy
Founded Date	2020	2018	2017	2019
Total funding	$5,9M	$30,3M	$43M	$4,5M
Latest Round	Seed	Series A	Series A + Grant	Seed
Vehicle	Daytona	RFA One	Skyrora XL	EOS
Payload to LEO	450 Kg	200 Kg	315 Kg	10 Kg
Stages	2	2	3	1
Length	19 m	30 m	23 m	4 m
Testing launch	2023	2022	2023	2023
Propellant	RP – 1 / LOX	RP – 1 / LOX	RP – 1 / HTP	Bio-butane/H_2O_2

Table 5 - continued.

Among companies reported in Table 5 and Table 5 - continued, Astra is the most developed on both financial and operating perspective. Despite recently founded (in 2016), the company already raised about $300 millions through several financing rounds, went public in July 2021 (first launch company to be traded on financial markets, reaching a $2,1 billion valuation), and it's planning first commercial flight for the end of summer 2021 (Etherington, 2021). Astra also partnered with Planet[14] (Astra, 2021) and won a $8 million contract from NASA to dispatch a constellation of CubeSats for the TROPICS mission in 2022 (NASA, 2021), officially becoming a competitor of more established launch companies such as Rocketlab.

Isar Aerospace is one of European leading newcos in the small launch segment. Founded in 2018, it recently raised $165 million in Series B marking the largest round to date in European space launch scene. The company plans its maiden launch for mid-2022, but already boasts paying contracts with AirBus, and has singed exclusive agreement with the Norwegian launchpad Andøya Space, speeding up in its developmental timeline (Alamalhodaei, 2021).

Other newcos reported in table 5 are relatively greener and are still validating and developing their technologies. Each of them tries to tackle the segment differently, offering innovative solutions and approaches: HyImpulse is committing on a hybrid liquid/solid propulsor conceived for combining advantages of the two components (re-ignitable and throttable as a liquid rocket but safe and reliable as a solid one); RFA aims at rockets' lowest production costs to ensure competitive pricing ; Launcher is working to develop the most efficient rocket, and bets on a third cargo stage which is compatible with SpaceX's Falcon 9; Phantom Space offers greater payload capacity to dispatch CubeSats, ESPA class satellites, and any other custom spacecraft; Skyrora is implementing a wide portfolio of solutions to address any emerging need from customers (i.e. orbital and suborbital missions with different payloads configuration).

In general, each startup and newco tries to actualize its own vision through a peculiar strategic implementation, eventually generating innovation at different levels of the segment (production processes, engine technologies, business models, etc.). However, all launchers implemented by the previously mentioned companies share a crucial characteristic: they are all multi-stages vehicles.

Multi-stages vehicles (generally two or three phases) are conceived for optimizing the spaceflight: first stage is designed to fly through the atmosphere, whereas second and upper stages are made for sub-orbital and orbital flights (i.e. for little atmospheric pressure and in-vacuum flight). However, current multi-stages RLVs can only recover the propulsor for atmospheric flight, while upper components are "expendable". Some major companies are addressing considerable funds in R&D for developing reusable second and upper stages, especially SpaceX with Starship (in development since

[14] USA satellite manufacturing company.

2016, aims at testing by end 2021) and Relativity Space[15] with Terran R[16] (entering development phase in 2021, testing aimed by 2024), but technical implementation is still complex (Berger, 2021). In addition to expendability of components, multi-stage rockets also demand launching site that match extreme environmental requirements, as stages' separation procedure generates dangerous debris that could damage neighboring areas. Such safety standards generally increase with launchers' dimension and may become very stringent, considerably slowing down operations (SpaceX is validating the launch of Starlink satellites from offshore spaceports to avoid environmental safety issues).
With respect to previously examined newcos, Sidereus is working on a completely different solution, developing a single-stage-to-orbit (SSTO) vehicle: EOS.

Sidereus is currently developing the operable prototype of EOS, which is so far smallest (and possibly the sole) fully reusable SSTO (up to 10 times) ever conceived, with only 3,75 meters of height, 1 meter of base diameter, and 70kg of unladen weight resulting in 2000kg of gross weight (Sidereus Space Dynamics, 2021).
Implementing an SSTO has several operative and business implications: a single-stage launcher is less efficient than a two-stages because it requires a structural balance that allows flight in both atmosphere and vacuum. Such inefficiency made SSTOs commercially unattractive until few years ago. However, increasing prominence of CubeSats has given these launchers a purpose, since reduced capacity and lower cargo weights mitigate flight inefficiency while allowing faster execution. Moreover, SSTO have lower environmental risks during launching, as there is no separation of stages and no debris generation, making these vehicles suitable also for launching sites close to inhabited centers.
Concerning EOS specifically, the vehicle is fully autonomous, able to self-drive through telemetry, and it is so compact that requires almost no infrastructure to be operated. In case of errors or deviations, it is provided with a guided flight and reentry system that executes abortion and that operates the landing back to the port, ensuring safe launches even in populated areas. In detail, during abortion procedure the launcher ejects remaining propellants (venting allows to reduce weight up to 80 Kg, which correspond to unladen mass plus maximum payload) and dispatches its parafoil for safe reentry. If needed, manual remote override is also possible.
Small dimensions, safety characteristics, and easiness in operations, allow EOS to be prepared within few hours and to be launched almost from wherever in a couple weeks (depending on authorizations

[15] USA aerospace manufacturing company founded in 2015. It develops launch vehicles and rocket engines for commercial orbital launch services. Raised $650 million in its latest series E round in 2021 ($1,3 billion so far).
[16] Fully reusable launch vehicle designed to compete with Falcon 9. It has expected payload mass capacity of 20 tons.

required). The result is a dramatic cut in operators' waiting time (which is usually between 9 months and 2 years for a traditional rideshare) and in incredibly enhanced operability (Principi, 2021).
These characteristics and technologies define EOS as a Multipurpose Orbital Drone (MOD), opening a wide range of implementable services. For now, Sidereus aims at offering periodic rideshares and fully dedicated missions at 13000 $/Kg, being able to dispatch into LEO with two different configurations: 10 Kg payloads to 550 km SSO and 24 Kg to 350 km at 13° (Sidereus Space Dynamics, 2021). However, the vehicle could service other advanced missions at customized prices such as such iterative R&D (i.e. sub-orbital and orbital testing, implementable through repeated launches enabled by fast-execution), drive-it-yourself (enabling customers such as companies, universities or even spaceports to autonomously launch EOS thanks to its self-driving capabilities), point-to-point (sub-orbital fast transportation is enhanced by safety characteristics), positioning and refurbishment of CubeSats. This latter typology of mission has raised significant clamor around Sidereus: when a unit of a constellation stops working properly, it threatens the functioning of the whole network. Traditional refurbishment solutions are not efficient because incur in typical (very long) launch waiting lists, potentially leading to down in services and severe economic damages. EOS' fast executability allows instead almost instant dispatchment of a new substitute CubeSat, collocating the payload in the orbit required, eventually ensuring prompt intervention and continuity in constellation's services.
Even if commercialization of EOS is expected for 2023, Sidereus' innovative propositions allowed the startup to receive several letters of interest and even some requests for launching contracts from potential customers. However, to achieve its first successful launch and to actualize the disruption it seems capable of, Sidereus will require huge funding and consistent technical results. And the two things are closely tied to each other.

As previously discussed, USA is leading in terms of VC investments in space startups, with several European newcos moving to West for accessing funds and benefitting from network's spillovers. However, significant initiatives are now taking place in Europe as well, with Italy being a forerunner. Notably, Primo Ventures (former Primomiglio SGR, leading Italian VC) has established Primo Space, one of the few entities in the world solely focused on seed and early-stage investments in space tech projects. The fund achieved a first closing of €58 million in July 2020 and aims at a final reach of more than €80 million by the end of 2021 (European Commission, 2020). Primo Space's first commitment was signed in December 2020, with €1,5 million investment in Aiko[17]. A second deal

[17] Italian startup that develops A.I. for space missions' automation.

was then closed in January 2021, with the fund co-leading a €5 million investment in Leaf Space[18] (Leaf Space, 2021). The two companies already have paying customers and are mainly addressing funds to business' development.

Concerning Sidereus's funding records, the startup initially aimed at raising for developing a technology to allow satellites moving across orbits. The project rapidly evolved into a proper launcher (eventually identified with EOS), for which the newco received a €70K pre-seed investment from MAIN[19] in 2019 (NA Startup, 2020). Funds were addressed to develop a non-functioning MVP of EOS, which allowed Sidereus to make it through, closing a relevant seed deal in mid-2021 with Primo Space itself. The round consists of a comprehensive €4,5 million funding divided in two tranches. In detail, the company directly received a first injection of €1,5 million (one third of the overall agreed investment, with €0,5 millions addressed by CDP[20]) to develop a first partially working version of EOS, while second tranche's disbursement (€3 million) depends on two technical milestones: full duration static fire (successful ignition and roll out of engines), and low-altitude lift-off and reentry (Principi, 2021). Such second tranche will be pivotal to develop the technology and allow a substantial series A round, whose dimension will reasonably affect EOS' realization and eventual commercialization.

In the meantime, Sidereus has managed to file three patents for enabling technologies concerning proprietary fuel tanks, design and assembling of COTS and proprietary components, and the engine (which is fueled by hydrogen peroxide and bio-butane, two green propellants alternative to RP – 1 that make EOS carbon-neutral). Obviously, space companies' projects and results are severely screened by authorities and consultants. Sidereus itself went through several examinations for accessing funds and for acquiring operative permissions. The startup also traced contingent and alternative plans in case technology validation may lead to negative results (i.e. in the extreme case of orbital SSTO's rejection the company shall be able of readdress its technology to a different type of vehicle), or in case raising will exceed or miss budgeted funding. The magnitude of the Series A may indeed significantly influence company's schedule and agenda: a limited injection may oblige to slow down in the developmental process of EOS or to give up some degree of innovation in feasibility's sake, while an oversized round may instead sufficiently support the implementation of a bigger – and more costly – version of EOS, allowing the company to target a wider portion of the market from the very first commercialization. Indeed, current EOS' design only allows two payload's configurations - 10 kg and 36 kg according to orbit required - which are very limited and can only dispatch a series of CubeSats at most, eventually shrinking targetable market segment.

[18] Italian ground segment as-a-service company – Gsaas – focused on microsatellites.
[19] Management Innovation, which expressed current member Chairman of the board.
[20] Cassa Depositi e Prestiti. Italian financial institution with participations in several innovative startups.

What has been discussed so far unequivocally points out R&D as the core activity. Sidereus has indeed set its HQ in Turin[21] to exploit the economies of scope of the industrial pole, and to capitalize widespread knowledge and competences of companies that supply and produce required components. In fact, the startup currently outsources production of subsystems. Assembly procedures and data analysis are instead operated internally by the development team (which accounts for the greater share of R&D expenditure, and generally of whole company's outflows). In the long term the goal is to verticalize the supply chain and integrate production as much as possible, with some items that could also be easily 3D printed, but at current stage it is not financially feasible as it would imply high upfront costs (Principi, 2021).

Being cost efficient in such an expensive sector is indeed crucial, and early-stage companies must squeeze value from each penny they have managed to raise. Such approach poses COTS as core components. In detail, most of COTS used for EOS prototype are qualified as "automotive components". This happens because in an embryonic validation phase (where official certifications are not relevant and only technical properties and specifications matter) such choice permits to save considerable funds during production and testing procedures, allowing evolutive R&D: systems are periodically pushed to structural failure and re-designed and improved according to data collected. Such iterative approach generates several generations of systems with incremental performances.

Once the vehicle will have passed lab phase, testing flights will start. However, Sidereus will obviously need authorization from local entities to operate launches. The startup is already working with ENAC[22] to reach such agreements, but Italian bureaucracy may require quite long time. In the meantime, to avoid delays in the developmental phase, the newco has already reached agreements with other EU countries and spaceports to run EOS test flights (Principi, 2021).

If EOS will eventually become operative and reach commercialization, the company will have to accurately define its marketable strategy. Despite Sidereus' declared vision of allowing private entities to possess their own space vehicle (hence a traditional asset sale model), the company currently provides target pricing for usage fee. However, EOS characteristics may support the implementation of several revenues streams such as a kind-of-subscription fee (i.e. for universities and research labs) allowing periodical dispatching of CubeSats; or a lending/leasing model, allowing spaceports to autonomously service operators. Such a wide portfolio of solution and marketable strategies could furtherly and dramatically push EOS diffusion, and severely enhance space accessibility.

[21] Turin and Piedmont host the biggest industrial pole in Italy, gathering the production and supply chain of several sectors, such automotive, aerospace and mechatronics.
[22] Italian national entity for civil aviation which is responsible for technical regulation of the segment.

To sum up everything that has been stated so far, compact RLVs' segment and Sidereus' case clearly highlight that:

1) New trends and business opportunities are attracting startups that are generate consistent innovation at all levels of the industry.
2) Competition is fierce and happens at the frontier of technology, with R&D being core.
3) The industry is capital intensive and access to funds is crucial for developing, implementing, and eventually commercializing space projects. Hence, funds accessibility directly influences marketable strategies of innovative solutions.
4) Networks, partnerships, and agreements are essential means to succeed, as they enhance cooperation, generate spillovers, guarantee visibility, and (together with technological achievements) ground funding requests.
5) Newcos generally need several years before they can finally reach the market and service customers.

In such a competitive and highly demanding scenario, Sidereus is validating its technology and business model starting from the very bottom of the market (currently represented by CubeSats launches) with the goal of allowing more operators to dispatch their payloads, eventually enhancing space economy's democratization. Such approach clearly recalls and matches Christensen's orthodox disruptive innovation theory according to which "a product or service initially takes root in simple applications at the bottom of the market, typically by being less expensive and more accessible, and then relentlessly moves upmarket, eventually displacing established companies". This is exactly what Sidereus aims for: overcoming industry's traditional complication by leveraging simplicity, accessibility, and affordability, with the final goal of escalating the sector by increasing cargo volumes and widening portfolio of services, eventually disrupting the whole industry, untapping true market potential, and reshaping the competitive environment.

8 Conclusions

In the end, all the evidence and trends discussed through the paper concerning industry's booming turnover and new investments patterns in private ventures, together with issues concerning the risk of industry's overheating and overexcitement, characterize a scenario which is considerably different from the distributed one reported by Whitney (2000) and supported by other research papers previously investigated: the gradual and long-lasting commercialization process that was initiated by liberalization in the communication services has now spread through all verticals and segments of the industry, resulting in new business opportunities, and enhancing a renovated entrepreneurial approach. Moreover, increased capital accessibility, flourishing forecasts, and rising prominence of major newcos, are furtherly attracting innovative entrants, eventually shaping a dynamic and fast-evolving competitive scenario.

Concerning the role played by major newcos and by other entering startups, all these entities are challenging the current paradigm, even if through different approaches. Specifically, major space newcos such as SpaceX, Blue Origins, Virgin Galactic, are marking astonishing results by offering and implementing innovative solutions in capital-intensive verticals at the frontier of the industry. However, these companies cannot be orthodoxically defined as disruptive, since they have raised enormous amount of funds from the very beginning, and since they have entered the industry directly tackling high-end and mass segments. Such major newcos are opposed to potentially (properly) disruptive entrants like Sidereus, which can instead rely on considerably lower capitals and that are obliged to make a virtue out of necessity, tackling low-end and unserved market segments to validate their innovative solutions. However, competition is becoming fierce even in such marginal verticals, and insights provided by the developed regression model suggest that an exponentially growing number of innovative newcos will actively enter the market in the next future, possibly targeting these less-demanding segments themselves.

Such peculiar contingency may generate a process of disruption within destruction, in which major newcos are directly competing with incumbent entities at high-end and mass level, while being simultaneously exposed to the undercut of an increasing number of potentially disruptive startups that are approaching low-end segments with the final goal of escalating upmarket.

However, main concerns regard whether these entrants will eventually be able to actualize the disruption they seem capable of, or whether they will be restrained by enormous capital requirements and by extremely long developmental processes that space economy demands, and which may finally allow major newcos to move downwards and absorb, possibly internalize, disruption. Such latter scenario would generate a paradox in the theoretical debate, as the industry will eventually be disrupted (new solutions will result in completely new paradigms and accessibility would be enhanced) but commercialization of disruptive innovation will be carried out by major (i.e. creatively destructive, not properly disruptive) space newcos.

Despite such theoretical controversies, it is senseful to finally affirm that sustained commercialization and all its subsequent implications are attracting an increasing number of innovative newcos that could disrupt the industry and dramatically reshape not only the space economy, but possibly the whole technological paradigm as it is of today.

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10 Executive Summary

Space economy is a high-tech industry that operates at the frontier of technology and innovation. The sector is currently expanding, and incumbent entities are benefitting from growing demand and increasing business opportunities. However, the sustained commercialization process is also allowing several newcos to enter the industry and to provide innovative solutions at different levels of the market, possibly altering established competitive paradigm. This contingent scenario portrays a dynamic environment which might be subject to dramatic changes over the next few years.

One of the first and most recalled theories of innovation is the "creative destruction" enunciated by Schumpeter in mid of the XX century. It portrays innovation as a "process of industrial mutation that continuously revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one" (Schumpeter, 1942). In such perspective, economic and technological development are innovation-driven processes that uniquely shape and distinctly characterize occurring business cycles. Schumpeter's gale firstly captured the destructive component that belongs to some kinds of innovation. Successively, such component was furtherly investigated by Clayton M. Christensen and his collaborators, resulting in the first enunciation of "disruption". The concept describes a process whereby a smaller company with fewer resources successfully challenges established entities either by servicing untargeted segments of the market, or by turning noncustomers into customers (Christensen, 1995). Specifically, while incumbents target the most profitable (and demanding) segments of the market offering incremental solutions, entrants that prove disruptive begin focusing on neglected pools and introduce and validate alternative (possibly cheaper) solutions. If entrants are able to move upmarket and acquire significant shares of mainstream customers while preserving the advantages that drove their early success, disruption has occurred. The newly emerging competitive environment is eventually characterized by completely new benchmarks and dynamics, and by increased accessibility.

Concerning space economy, the industry proves valuable to furtherly discuss about creative destruction statement and disruptive innovation theory, with the goal of understanding whether entering newcos will eventually be able to creatively destruct – or possibly disrupt – space industry.

Space economy's competitive scenario has already dramatically evolved over the years. Originally, the industry was severely tied to governmental entities, with the public sector being the main, almost the sole, investor in space projects. Researchers emphasize how "Space industry was enabled by, and grew because of, institutional customers" (Hiriart, 2009). However, after gradual and progressive liberalization, private companies managed to enter the sector, eventually gaining relevance within the industry. Specifically, private endeavors were mainly spurred by liberalization in the communication segment, with major companies in commercial satellite platforms such as Northrop Grumman, Lockheed Martin, and Thales Alenia achieving outstanding performances over the years, and sustaining commercialization process of the whole industry, progressively enhancing new business opportunities along the entire supply chain.

To provide a contingent perspective on the evolution of market dynamics, industry's demand structure over the years shall be considered. Barbaroux (2016) examined 1593 launches over the period 2000-2013, grouping and analyzing data concerning sector's main operators. It emerges that governmental operators (mainly national agencies) account for about 70% of the spaceflights sampled, with the remaining part consisting of both private companies and non-governmental agents (e.g., corporates, universities, research labs). However, despite marked prominence of public spaceflights, Shove (2005) stresses out that already in 2003 about 83% of total revenues generated by the whole sector came from commercial applications, which are strictly linked to interests expressed by private companies rather than to governmental operations. This proportion was also confirmed by the OECD in 2011 and only slightly adjusted over the last ten years.

Hence, demand structure's composition appears quite stable over the years concerning both the nature of operators and the percentage of revenues generated by public and private sectors: whereas governmental entities are responsible for most spaceflights, commercial payloads generate the higher fraction of financial transactions.

Concerning instead overall industry turnover, despite OECD (2018) affirming that many commercial space activities are still not covered by official statistics, revenues of space economy have been booming over the last 15 years, rocketing from the $186 billion in 2005 to $424 billion in 2019. The massive growth rate is mainly due to technological progress and to enhanced commercialization that generated downstream application of space-related technologies, and that allowed new market segments branching out. Forecasts for the future are also flourishing. Morgan Stanley investigated space economy's frontier for the next twenty years focusing on a baseline scenario where the sector is mainly driven by downstream applications. Even if the study adopts an investor-concerned perspective and avoids making any prediction on emerging and pioneering upstream markets, the industry is expected to reach $1 trillion by 2040 (Morgan Stanley, 2020). However, the upstream development of space market could potentially lead to even more optimistic and barely foreseeable results. Merrill Lynch even predicts a 3x growth rate of the industry with respect to Morgan Stanley, resulting in $3 trillion of expected turnover by 2040 (Sheets, 2017).

In the end, even if the proportion of operators' natures (i.e. public or private) and their contribution to revenue generation have remained fairly stable since 2000 onward, and even if a prudent analysis would considerably net optimistic expectations, the industry already marked astonishing results and the ongoing commercialization process is already generating several flourishing downstream and upstream markets, untapping true market potential. Hence, industry has already grown so big to ground and justify the claim of a new stage of space economy. However, to provide a more contingent perspective, investment patterns characterizing the competitive scenario shall also be discussed.

Public funds have historically played a crucial role in sustaining and fueling space economy's development, with some governments addressing shares of public expenditure consisting in several hundreds of million USD. To properly understand public sector's commitment in space development the share of civil Government Budget Allocations for Research and Development (GBARD) addressed to space economy (space GBARD) shall be analyzed. The indicator has been proposed by OECD and synthetizes all actual R&D investments falling under the category "exploration and exploitation of space" and includes items such as fundamental and applied R&D activities, and space-related infrastructures such as laboratories and launching systems. In detail, it is worthful to notice that after years of sustained growth, aggregate monetary value of space GBARD from OECD countries has been plateauing over latest periods. These records somehow collide with rocketing performance of the space sector, which has instead experienced sustained growth especially during the last five years. Such evidence may then suggest that public investors might have lost their function as prime engine of industry advancement, probably in favor of private agents. Despite this, public investments are still surely essential in ensuring a flourish and attractive economic environment.

But the role of public entities goes beyond the mere commitment of funds. In fact, besides directly investing in R&D and infrastructures, many governments have also tried to implement regulatory frameworks aiming at spurring private endeavors within different branches. To provide a grounded and properly referenced perspective on the state of entrepreneurship and innovation in the sector, an analysis on institutional investors' commitment shall be developed, as such investors publish due diligence on their operations and are mainly focused on private ventures.

In detail, evidence shows that the number of investors committing in new space ventures and that the number of startups accessing capitals are dramatically increasing. BRYCE Space and Technology identifies 967 different investors and an overall commitment of about $27 billions over the period 2000-2019, most of which during the last 10 years, with 2019 registering a $4 billion peak.

Such funding has been mainly raised through Business Angels (25%) and VC (50%), with remaining share covered by debt, private equity, and corporate operations all together. Current developmental level of the industry is hence clearly presented: most financed startups are still at the beginning of their business life cycle, which implies high risk, low or null profits, and high burn rate. These characteristics determine limited number of M&A operations, very low commitment from later stage investors such as private equity firms, and instead great participation from Business Angels and VCs. However, capitals are not evenly distributed across startups. In detail, over the period 2015-2019 Blue Origin has implemented self-capitalizations rounds for about $3,5 billions, and SpaceX and OneWeb have respectively raised about $3 billions and $3,4 billions through several VC rounds (Crunchbase, 2021). Specifically, these three companies have raised about $9 billions out of the $17 billions globally committed over the period 2015-2019, collecting by themselves more than half of the funds addressed by investors.

A first glance may suggest that these companies are draining out most of the capitals invested in the sector, leaving drops of financing to other startups. However, a more concerned analysis may lead to the hypothesis that the whole sector has been enhanced by these very companies, which have acted as forerunners, validating new solutions, and drawing investors' attention onto new space business. This query is furtherly discussed in the multivariable regression model.

The model aims at portraying how industry turnover and investment patterns (i.e. level of public investment, private commitment in space startups, and funds raised by major newcos) impact on the number of space startups accessing funds. For consistency purposes, the model is built on actual data collected over the last 20 years by entities that provide official disclosure and full references on their materials (concerning financing rounds, only VC funding are considered).

As extensively discussed in the methodology section, sample's dimension does not allow to express data's full explanatory potential. This is because new space's competitive environment is relatively young and provides limited observations concerning space startups and emerging newcos. Such peculiarity is obviously a limit to the study, but also a source of value and of experimental beauty since it implies working at the frontier of events. Moreover, statistical analysis provides sharp trends and clear paths, eventually grounding the willingness to accept a compromise between a lower statistical explanatory soundness of the model, and the valuable business insight it may provide.

Model 1 is a linear regression which presents:

- FUNDED (dependent variable): new space ventures accessing capital on a given year.
- REV: yearly revenues generated by the entire space industry.
- NVCINV: annual aggregate VC investment in emerging space companies excluding funds raised by SpaceX and OneWeb.
- SXOW: capitals raised by SpaceX and OneWeb.
- SGBARD: space GBARD.

The determination coefficient of the model proves a good fit. However, SGBARD's individual P-value does not match the 5% requirement, and the variable appears as the least significant. As a matter of fact, comparative analysis shows that aggregate public investment of OECD countries has remained relatively stable over the last years, as opposed to the number of financed startups which has been constantly increasing, especially since 2010 onwards. Therefore, even though public investments have undoubtedly ignited initial private endeavors, they may currently play a less relevant role in determining space startups' emergence. Conceptually, it may also be the case that a minimal bulk level of public investments might be required to enhance private commitment, and therefore a significantly lower SGBARD may negatively affect other explanatory variables, eventually affecting the dependent variable as well. Obviously, such inference cannot be directly derived from this regression, but the point may deserve further investigation.

Model 2 presents same independent variables of Model 1 apart from SGBARD which has been removed in the tentative of improving model's soundness. After the adjustment, determination coefficient remains about 97%, confirming the good fit of the model, and all p-values of the explanatory variables are fitting the required significance level of 5%, strengthening regression' validity. Specifically, the model predicts that:

- Despite being significant, REV coefficient is marginal with respect to other variables. In detail, every extra billion USD in industry turnover has only a limited impact on the number of financed startups, ceteris paribus.
- Each billion USD raised by SpaceX and OneWeb at VC level leads to about sixteen space startups accessing capitals, ceteris paribus.
- Every billion USD directly invested at VC level allows thirty-four new space ventures to close a funding round, ceteris paribus.

Hence, the model depicts a peculiar scenario where fund accessibility is just loosely linked to overall industry performance, and it is instead severely bond to private investors' commitment and major newcos' funding records, which are crucial in shaping investors' expectations. Not by chance, every and each achievement or failure from these iconic major newcos catalyze attention from the media and fuel investors' propension to invest, indirectly allowing an exponential number of emerging companies to access funding and to develop their innovative solutions.

Finally, the amount of funds directly invested in minor space ventures at VC level positively influences the number of startups accessing capitals. Most valuable insight emerging from this latter point is that the model predicts only 34 startups accessing capital for every extra billion USD invested at VC level, ceteris paribus. Such result suggests that the average round may consists of some tens of million USD, proving the industry as extremely capital intensive, even at early-stages.

In the end, after having analyzed main trends and path in the industry, Model 2 suggests that an increasing number of space startups will possibly access funding over the next periods and have the chance to develop and validate innovative solutions. Such consideration strongly supports the hypothesis of a possibly dramatically changing competitive environment, which could experience an unprecedent level of innovation, resulting in totally new competitive paradigms.

At the moment, new space economy basically presents two tiers of newcos: on the one hand major newcos which were born 10 to 15 years ago, and that are usually backed by visionary billionaires and/or by international entities; and an increasing number of minor startups (some of which have already raised significant funds though) which are competing to gain market shares, generally low-end or unserved. Even if financial and contingent conditions vary significantly between and within these two tiers, no space newco can be said to be self-sufficient and already fully sustainable. This is because all these companies, even the major ones, are still validating and developing their core products, services, and business models, requiring huge capital to finance their activities. SpaceX is an explicative example. The company is primarily focused on manufacturing and launching rockets and spaceships. It marked historical milestones for the industry, and it is probably the most established of the group. However, it has only recently achieved manned spaceflight (in mid-2020) and even if it is involved in several projects at the frontier of the sector, the sole source of revenue it can currently rely on is from launch services for dispatching satellites and for cargo transportation to the ISS.
Although company is expected to reach about $1,55 billion revenues in 2021, such turnover cannot properly sustain SpaceX's model and vision. The company has indeed resorted to several venture rounds raising more than $3 billions over the last five years. Such financing has pushed valuation up to $76 billions in 2021 (Trefis, 2021), resulting in 2021 in a Price-to-Sales multiple of 46,5x (multiples of incumbent competitors range from 1,5 to 2,5 (nasdaq, 2021)).
Hence, SpaceX can be reasonably considered as a successful space newco that could enhance creative destruction in the space industry over the next periods, probably being also one of the most established from a technological point of view. However, its peculiar financial and business contingency, together with the huge amount of funds that have been recently raised to support the development of core operations, restrain the newco within the boundaries of those companies that besides being fast scaling and highly innovative are not self-sustainable yet.

SpaceX is just one of emerging space ventures that have already reached a valuation of several billion USD. However, apart from Virgin Galactic and very few other newcos (i.e. Astra) no one has gone public so far. Investors and analysts firmly believe that these companies will mark astonishing performances over next periods. Therefore, remaining fully private allows to both shield against speculation (as these newcos are currently burning considerable amounts of cash generating low or null profits) and to maximize capital gain (as their value is expected to grow dramatically over the next decade). However, besides growing trends and widespread dynamism, a second and wiser glance would raise some concerns:

1. The average long-term investment horizon of the industry, in conjuncture with emerging lean (non-proven) business models, may end up in several newcos raising considerable amount of funds and eventually going belly-up before even servicing the first customer.
2. The sharply increasing number of entrants may require newcos to merge or partner up for consolidating operations in order to avoid the creation of a mosaic of cash-burning and underperforming companies.
3. Enthusiasm surrounding space activities may grow faster than actual commercialization, eventually leading to economic bubbles.

Evidence discussed portray a considerably evolved competitive scenario which is generally defined as “New Space”. Such new stage of space economy is characterized by emerging business opportunities, strengthened commercialization, and lower barriers for entrants, eventually resulting in increased competition and new means for innovative solutions at all levels of the supply chain.

Despite the renovated environment, satellites sector is still the most relevant segment. It includes manufacturing, launching, servicing, and application, which comprehensively generated $271 billions in 2019. Although launching and manufacturing respectively accounts for $5 billions and $12 billions only, they have been characterized by several investment opportunities since 2012 onwards. Specifically, Space Capital reports 556 financing rounds closed by innovative companies operating in these very two segments over the analyzed period, with respectively 300 deals in launching and 256 in manufacturing respectively (Space Capital, 2021). These numbers globally certify a dynamic scenario with several investment opportunities, and a fertile environment for private endeavors.

The broad range of services developed, and the high degree of sophistication and specialization reached by the industry, finally result in a wide portfolio of solutions provided: products and services vary significantly in technology used and in costs depending on the typology of satellites manufactured, on implementable applications, and on the launcher needed.

Despite such diversification, reduction in satellites’ cost and dimension has been a widely shared trend through the last decade: average commercial payloads have passed from several thousands of kilograms to some hundreds, with increasing dispatchment of minisatellites (100kg-500kg),

eventually spurring R&D for compact launchers. Electron rocket by RocketLab (one of the smallest operating launchers, with a height of 18 meters), was indeed conceived with the purpose of servicing small commercial satellite market, launching about 300 kg into generic LEO. It serves since 2018 starting from $5,7 million per ride (Etherington, techcrunch.com, 2020).
Considering that the Falcon 9 from SpaceX (70 meters tall) provides rides for about $60 million, which drop to $50 million for a reused vehicle, launching about 22.800 kg into LEO, Electron has considerably lowered the threshold for accessing space, becoming a leader in the segment.

However, despite new solutions offered, costs and dimensions remain relevant and still imply organizing rideshares for operators willing to dispatch microsatellites (10-100 kg) or smaller payloads, as well as servicing through conventional spaceports, eventually resulting in long waiting lists (from 9 months up to a couple of years) and decreased operability. All these issues cut off a significant share of potential operators (i.e. customers) which might be interested in cheaper and less committing launches for academic purposes, in-orbit testing, and other applications.
Concerning small launches, inefficiencies due to cost, operational, and dimensional unfitting, have been furtherly exacerbated by the recent rise of U-class spacecrafts, commonly known as CubeSats.
CubeSats are miniaturized satellites for space research that consist of multiple cubic modules of 10x10x10 cm, with a mass of about 1,33 kg per unit (nanosatellite). They were initially designed for academic purposes to let students experiment on cheap and maneuverable devices. However, progress in miniaturization procedures and technological development allowed to build and eventually dispatch CubeSats with improving functionalities, increasing operators' demand.
First launch happened in 2003, but only 75 modules had entered orbit by 2012. To date, more than 1500 CubeSats have been dispatched, most of which during the last few years, with 2021 registering a record of 702 launches scheduled or already executed (nanosats.eu, 2021).
Initially, U-modules were dispatched as secondary payloads in rideshare to occupy the small empty space remaining after major satellites, but their increasing prominence has generated a new market segment, aggregating a growing number of operators requiring compact launchers that could service at significantly lower cost and with greater efficiency. This emerging demand has spurred R&D and investments aimed at developing an alternative solution to rideshares in traditional vehicles, and to furtherly lower the thresholds for accessing space. These factors make the nanosatellites' launching segment extremely valuable for presenting a practical business case on how newcos are trying to tackle emerging business opportunities. In particular, the case of Sidereus Space Dynamics will be presented.

The company was founded in Italy in 2019 with the mission of democratizing access to the orbit by reducing space shipping costs, and with the vision of allowing private entities to possess their own launch vehicle for commercial and research proposes. Such ambitious goal is pursued through the development of a small (less than 4 meters tall), accessible, and reusable launch vehicle that could be operated by few people thanks to technological miniaturization, COTS, and innovative technologies. But before discussing strategic implementation, the competitive sector shall be presented.

Specifically, RLVs segment for small payloads is characterized by several newcos that are trying to gain their own spot in the market. Two of the most developed are Astra and Isar Aerospace. The first was founded in 2016, raised about $300 millions through several financing rounds, it's planning first commercial flight for the end of summer 2021 (Etherington, 2021). The latter was founded in 2018, recently raised $165 million in Series B, and already boasts paying contracts and exclusive agreements with partners and customers. Besides them, there is a copious group of fast-growing companies that is developing and validating innovative solutions. Some of the most ambitious are HyImpulse, RFA, Launcher, Phantom Space and Skyrora, with each startup trying to actualize its own vision through a peculiar strategic implementation, eventually generating innovation at different levels of the segment (production processes, engine technologies, business models, etc.).

However, all launchers implemented by previously mentioned companies share a crucial characteristic: they are all multi-stages vehicles. Multi-stages vehicles (generally two or three phases) are conceived for optimizing the spaceflight: first stage is designed to fly through the atmosphere, whereas second and upper stages are made for sub-orbital and orbital flights (i.e. for little atmospheric pressure and in-vacuum flight). However, current multi-stages RLVs can only recover the propulsor for atmospheric flight, while upper components are "expendable". Some major companies are addressing considerable funds in R&D for developing reusable second and upper stages, namely SpaceX and Relativity Space, but technical implementation is still complex (Berger, 2021).

In addition to costs linked to expendability of components, multi-stage rockets also need launching site that match extreme environmental requirements, as stages' separation generates dangerous debris that could damage neighboring areas. Such safety standards generally increase with launchers' dimension and may become very stringent, considerably slowing down operations.

With respect to previously examined newcos, Sidereus is working on a completely different solution, developing a single-stage-to-orbit (SSTO) vehicle: EOS.

Sidereus is currently developing the operable prototype of EOS, which is so far smallest fully reusable SSTO ever conceived. Implementing an SSTO has several operative and business implications: a single-stage launcher is less efficient than a two-stages because it requires a structural balance that allows flight in both atmosphere and vacuum. Such inefficiency made SSTOs commercially unattractive until few years ago. However, increasing prominence of CubeSats has given these launchers a purpose, since reduced capacity and lower cargo weights mitigate flight inefficiency while allowing faster execution. Moreover, SSTO have lower environmental risks during launching, as there is no separation of stages and no debris generation, making these vehicles suitable also for launching sites close to inhabited centers.

Concerning EOS specifically, the vehicle is fully autonomous, able to self-drive through telemetry, and it is so compact that requires almost no infrastructure to be operated. In case of errors or deviations, it is provided with a guided flight and reentry system that executes abortion and that operates the landing back to the port, ensuring safe launches even in populated areas.

Small dimensions, safety characteristics, and easiness in operations, allow EOS to be prepared within few hours and to be launched almost from wherever in a couple weeks. The result is a dramatic cut in operators' waiting time (which is usually between 9 months and 2 years for a traditional rideshare) and in incredibly enhanced operability (Principi, 2021).

These characteristics and technologies open a wide range of implementable services. For now, Sidereus aims at offering periodic rideshares and fully dedicated missions at 13000 $/Kg. However, the vehicle could service other advanced missions at customized prices such as such iterative R&D (implementable through repeated launches enabled by fast-execution), drive-it-yourself (enabling customers ì to autonomously launch EOS thanks to its self-driving capabilities), point-to-point (enhanced by safety characteristics), positioning and refurbishment of CubeSats. This latter typology of mission has raised significant clamor around Sidereus: when a unit of a constellation stops working properly, it threatens the functioning of the whole network. Traditional refurbishment solutions are not efficient because incur in typical (very long) launch waiting lists, potentially leading to down in services and severe economic damages. EOS' fast executability allows instead almost instant dispatchment of a new substitute CubeSat, collocating the payload in the orbit required, eventually ensuring prompt intervention and continuity in constellation's services.

Even if commercialization of EOS is expected for 2023, Sidereus' innovative propositions allowed the startup to receive several letters of interest and even some requests for launching contracts from potential customers. However, to achieve its first successful launch and to actualize the disruption it seems capable of, Sidereus will require huge funding and consistent technical results. And the two things are closely tied to each other.

Concerning Sidereus's funding records, the startup firstly received a €70K pre-seed investment in 2019 (NA Startup, 2020) to develop a non-functioning model of EOS. The MVP allowed Sidereus to make it through, closing a relevant seed deal in mid-2021 with Primo Space. The round consists of a comprehensive €4,5 million funding divided in two tranches: first one directly disbursed, and second one (€3 million) bounded to two technical milestones: full duration static fire (successful ignition and roll out of engines), and low-altitude lift-off and reentry (Principi, 2021). Such second tranche will be pivotal to develop the technology and allow a substantial series A round, whose dimension will reasonably affect EOS' realization and eventual commercialization.

In the meantime, Sidereus has managed to file three patents for enabling technologies concerning proprietary fuel tanks, design and assembling of COTS and proprietary components, and the engine. Obviously, space companies' projects and results are severely screened by authorities and consultants. Sidereus itself went through several examinations for accessing funds and for acquiring operative permissions. The startup also traced contingent and alternative plans in case technology validation may lead to negative results, or in case raising will exceed or miss budgeted funding. The magnitude of the Series A may indeed significantly influence company's schedule and agenda: a limited injection may oblige to slow down in the developmental process of EOS or to give up some degree of innovation in feasibility's sake, while an oversized round may instead sufficiently support the implementation of a bigger – and more costly – version of EOS, allowing the company to target a wider portion of the market from the very first commercialization. Indeed, current EOS' design only allows two payload's configurations that can only dispatch a series of CubeSats at most, eventually shrinking targetable market segment.

What has been discussed so far unequivocally points out R&D as the core activity. Sidereus has indeed set its HQ in Turin to exploit the economies of scope of the industrial pole, and to capitalize widespread knowledge and competences of companies that supply and produce required components. In fact, the startup currently outsources production of subsystems. Assembly procedures and data analysis are instead operated internally by the development team (which accounts for the greater share of R&D expenditure, and generally of whole company's outflows). In the long term the goal is to verticalize the supply chain and integrate production as much as possible, but at current stage it is not financially feasible as it would imply high upfront costs (Principi, 2021).

Being cost efficient in such an expensive sector is indeed crucial, and early-stage companies must squeeze value from each penny they have managed to raise. Such approach poses COTS as core components, since limited costs allow evolutive R&D: systems are periodically pushed to structural failure and re-designed and improved according to data collected. Such iterative approach generates several generations of systems with incremental performances.

Once the vehicle will have passed lab phase, testing flights will start. However, Sidereus will obviously need authorization from local entities to operate launches. The startup is already working with ENAC to reach such agreements, but Italian bureaucracy may require quite long time. In the meantime, to avoid delays in the developmental phase, the newco has already reached agreements with other EU countries and spaceports to run EOS test flights (Principi, 2021).

If EOS will eventually become operative and reach commercialization, the company will have to accurately define its marketable strategy. Despite Sidereus' declared vision of allowing private entities to possess their own space vehicle (hence a traditional asset sale model), the company currently provides target pricing for usage fee. However, EOS characteristics may support the implementation of several revenues streams such as a kind-of-subscription fee allowing periodical dispatching of CubeSats, or a lending/leasing model, allowing spaceports to autonomously service operators. Such a wide portfolio of solution and marketable strategies could furtherly and dramatically push EOS diffusion, and severely enhance space accessibility.

To sum up everything that has been stated so far, compact RLVs' segment and Sidereus' case clearly highlight that:

1. New trends and business opportunities are attracting startups that are generate consistent innovation at all levels of the industry.
2. Competition is fierce and happens at the frontier of technology, with R&D being core.
3. The industry is capital intensive and access to funds is crucial for developing, implementing, and eventually commercializing space projects. Hence, funds accessibility directly influences marketable strategies of innovative solutions.
4. Networks, partnerships, and agreements are essential means to succeed, as they enhance cooperation, generate spillovers, guarantee visibility, and (together with technological achievements) ground funding requests.
5. Newcos generally need several years before they can finally reach the market and service customers.

In such a competitive and highly demanding scenario, Sidereus is validating its technology and business model starting from the very bottom of the market (currently represented by CubeSats launches) with the goal of allowing more operators to dispatch their payloads, eventually enhancing space economy's democratization. Such approach clearly matches Christensen's disruptive innovation according to which "a product or service initially takes root in simple applications at the bottom of the market, typically by being less expensive and more accessible, and then relentlessly moves upmarket, eventually displacing established companies". This is exactly what Sidereus aims for: overcoming industry's traditional complication by leveraging simplicity, accessibility, and affordability, with the final goal of escalating the sector by increasing cargo volumes and widening portfolio of services, eventually disrupting the whole industry, untapping true market potential, and reshaping the competitive environment.

In the end, all the evidence and trends discussed through the paper portray a dynamic and mutating competitive environment that generated from sustained commercialization and increased capital accessibility.

Concerning the role played by major newcos and by other entering startups, all these entities are challenging the current paradigm, even if through different approaches. Specifically, major space newcos such as SpaceX, Blue Origins, Virgin Galactic, are marking astonishing results by offering innovative solutions in capital-intensive verticals at the frontier of the industry. However, these companies cannot be orthodoxically defined as disruptive, since they have raised enormous amount of funds from the very beginning, and since they have entered the industry directly tackling high-end and mass segments. Such major newcos are opposed to potentially (properly) disruptive entrants like Sidereus, which can instead rely on considerably lower capitals and that are obliged to make a virtue out of necessity, tackling low-end and unserved market segments to validate their innovative solutions. However, competition is becoming fierce even in such marginal verticals, and insights provided by the developed regression model suggest that an exponentially growing number of innovative newcos will actively enter the market in the next future, possibly targeting these less-demanding segments themselves.

Such peculiar contingency may generate a process of disruption within destruction, in which major newcos are directly competing with incumbent entities at high-end and mass level, while being simultaneously exposed to the undercut of an increasing number of potentially disruptive startups that are approaching low-end segments and niches with the final goal of escalating upmarket.

However, main concerns regard whether these entrants will eventually be able to actualize the disruption they seem capable of, or whether they might rather be restrained by enormous capital requirements and by extremely long developmental processes that space economy requires, and which may finally allow major newcos to move downwards and absorb, possibly internalize, disruption. Such latter scenario would generate a paradox in theoretical debate, as the industry will eventually be disrupted (completely new paradigms will emerge and accessibility would be enhanced) but commercialization of disruptive innovation will be carried out by major (i.e. creatively destructive, not properly disruptive) space newcos.

Despite such theoretical controversies, it is senseful to finally affirm that sustained commercialization, and all its subsequent implications, are attracting an increasing number of innovative newcos that could disrupt the industry and dramatically reshape not only space economy, but possibly the whole technological paradigm as it is of today.