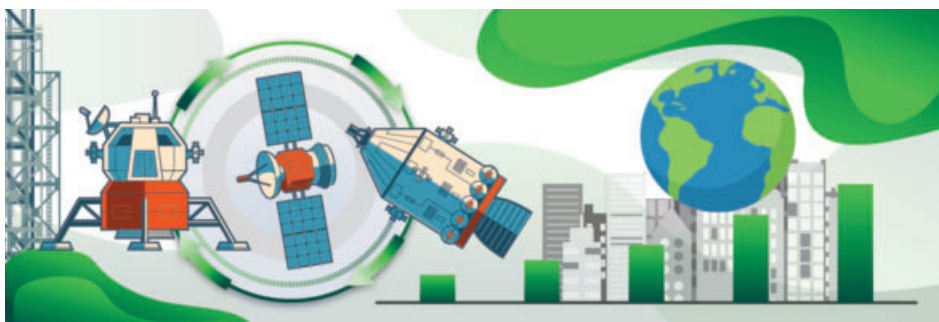


Patrizia Di Tullio

The New Space Economy

**Business models,
sustainability profiles
and accountability**

ECONOMIA



FrancoAngeli



MANAGEMENT

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Business models,
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This book was published with the support of the Department of Economic Studies - University “G. d’Annunzio” of Chieti-Pescara.

Cover by Elena Pellegrini

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1. Introduction

1.1. An overview of the book

The Space Economy is «the full range of activities and the use of resources that create value and benefits to human beings in the course of exploring, researching, understanding, managing, and utilising space» (OECD, 2012). For decades, only the governmental public actors have dominated the activities of this sector, motivated primarily by military and strategic purposes. However, space activities have recently become too expensive and technologically complex, making the national space agencies' resources insufficient. These conditions fostered public actors to favour the entry of private companies into the Space Economy.

Private companies developed new business models and activities for commercial purposes, marking the transition to the New Space Economy as a new phase of the space industry in which the space race between billionaires replaced the space race between countries (Weinzierl, 2018; Di Ciaccio, Cramarossa and Fatica, 2018; de Concini and Toth, 2019). In fact, the New Space Economy has attracted the investments of numerous venture capitalists and gained the interest of high-profile entrepreneurs who have diversified their activities through operating in new market segments such as space tourism and the extraction of resources and materials from space and other planets (Benjamin, 2018). However, at the same time, private companies needed the infrastructure and expertise of public actors to operate in the New Space Economy. Meanwhile, space industry public actors needed the investment, innovativeness and management approaches of private companies to keep the space sector competitive. Hence, government agencies and private companies have begun to collaborate through public-private partnerships (PPPs) and Collaborative Business Models (CBMs), leveraging each other's capabilities, resources and competencies and compensating for each other's weaknesses to create value (Lindgren, Taran and Boer, 2010; Weinzierl, 2018; Denis *et al.*, 2020).

These new organisational and strategic models created many advantages in managing and implementing space activities and projects in the New Space Economy. Yet, they also created some accountability questions coming from the challenge of understanding who should be responsible and for what in these collaborative projects (Shaoul, Stafford and Stapleton, 2012; Martin and Beaudry, 2015). These accountability issues also concern the social and environmental accountability of space activities. The New Space Economy's activities created both social and environmental benefits (e.g., advances in scientific and technological knowledge, weather and natural disaster forecasting) and criticalities (e.g., space debris, biological contamination) to humanity, the natural environment, and space system (Weinzierl, 2018; Argentiero and Falcone, 2020). However, space companies' social and environmental accountability is still unexplored, and the risk that space activities will be developed with an anthropocentric approach makes the need to understand it compelling (Paikowsky, 2017). Furthermore, these accountability concerns are exacerbated by an outdated regulatory framework about the new actors and commercial purposes of space activities in the New Space Economy and the lack of mechanisms to hold companies accountable (Sanna, 2021; Freeland and Piper, 2022).

This study analyses the New Space Economy from an accounting and managerial perspective through a review of multidisciplinary academic literature, reports from international organisations (e.g., Organisation for Economic Co-operation and Development - OECD, United Nations), space agencies (e.g., European Space Agency - ESA, National Aeronautics and Space Administration - NASA), international consulting firms (Bryce Tech, McKinsey & Company), and information from qualified secondary sources such as trade journals and online blogs (e.g., Engineering and Technology, Space.com) on the New Space Economy. The manuscript explores the new strategic and organisational approaches and business models enabled by the New Space Economy, the evolution of the regulatory framework of the Space Economy, and the social and environmental benefits and criticalities of space activities. In this regard, it also analyses private space companies' social and environmental information by analysing some of their sustainability reports and websites. The results of this study open up reflections on the sustainability of new business models and the social and environmental accountability of companies operating in the New Space Economy. Therefore, it draws possible future research streams to investigate the New Space Economy from a management and accountability perspective.

1.2. Theoretical and practical contributions

This study sheds light on some management and accountability traits of the New Space Economy by analysing business opportunities, new business models and organisational models of space actors. In particular, it explores the characteristics and limits of PPPs and CBMs in the space sector, so extending previous studies on hybrid forms of collaboration between public and private actors (e.g., Parker and Hartley, 2003, Villani, Greco and Phillips, 2017) and enriching the literature on CBMs (e.g., Lindgren, Taran and Boer, 2010; Rohrbeck, Konnertz and Knab, 2013; Mlecnik, Straub and Haavik, 2019).

This study builds on previous reflections on the Anthropocene and planetary boundaries, contributing to the debate on the need to revisit nature-human-business interactions (e.g., Whiteman, Walker and Perego, 2013; Bebbington *et al.*, 2020). It provides an overview of the social and environmental benefits and criticalities of space activities, so emphasising the need for a long-term strategy toward sustainable development of the space industry, taking into account the right of future generations and the aims of avoiding irreversible damage to the Earth and space environment. It also suggests the need for accountability for public and private space companies that can act toward this purpose by voluntarily adopting a sustainable approach to their activities.

In this vein, this study investigates space companies' social and environmental accountability, which has so far been overlooked by empirical research on the New Space Economy. Indeed, empirical accounting studies in the New Space Economy are mainly based on interviews with academic researchers, practitioners and experts in the space sector and aim to understand the nature and extent to which management accounting can contribute to interdisciplinary advances in the space sector (Tucker and Alewine, 2021; Tucker and Alewine, 2022). Therefore, the main contribution of this study is to provide empirical evidence on corporate social and environmental accountability issues in the New Space Economy by analysing sustainability reports and websites of private space companies. This empirical analysis reveals that the space industry needs an international framework of standards to make space activities more sustainable and their actors more accountable. In this sense, several recent initiatives by international bodies aim to encourage social and environmental accountability. These initiatives have been collected and described in this study, providing insights for policy makers.

Institutional bodies have an essential role in bridging the regulatory gap and providing a significant impetus for advancing sustainability and accountability in the New Space Economy. Regulations, standards and ratings can

improve the production and spread of information on space activities' social and environmental impacts. This study identifies the most critical issues of the New Space Economy that need to be put on the regulators' agenda, such as setting standards for social and environmental reporting and accountability of space actors, the right of ownership of space resources and the boundaries of outer space.

1.3. Structure of the book

The remainder of the book is structured into four further chapters.

Chapter 2 defines the Space Economy and outlines some of its foundational and evolutionary traits. It examines the characteristics of the Old Space Economy and the New Space Economy in the academic literature and in the professional documents of international organizations that have dealt with this topic (e.g., European Investment Bank; Economic and Security Committee) to highlight their peculiarities and differences. It also analyses the key players, activities, and business opportunities characterising the New Space Economy and its future development. Finally, it presents a regulatory framework in the New Space Economy focusing on accountability and sustainability issues.

Chapter 3 focuses on the new strategic and organisational approaches and business models enabled by the New Space Economy. The analysis of the literature on PPPs and CBMs is enriched with data and information on recent space projects and missions carried out through collaboration between public and private companies. In this way, theoretical and practical aspects are compared and the accountability implications of the strategic and organisational approaches used in the New Space Economy are highlighted.

Chapter 4 explores the social and environmental accountability issues of companies operating in the New Space Economy. Specifically, it analyses the benefits and criticalities that space activities can produce at a social and environmental level. The results from the literature review are corroborated through empirical evidence coming from the analysis of the websites and sustainability reports of some private space companies. This evidence shows that space companies adopt an anthropocentric approach and prioritise and emphasise environmental and social benefits, neglecting the social and environmental issues of space activities. This condition is facilitated by the absence of any form of international accountability for private space companies. The study of the guidelines promoted to address the social and environmental concerns of space activities in the New Space Economy highlights

the significant role of institutional regulators in promoting greater accountability for space companies.

Chapter 5 closes the book with an overview of the research and concluding remarks, outlining the limitations of the study and the opportunities for future research on the business models, their sustainability and the accountability in the New Space Economy.

2. The Space Economy: definitions and key aspects

2.1. Introduction

The Space Economy concept identifies the whole space value chain that, starting from the traditional enabling pillars of the space industry, embraces the generation of innovative space-enabled services and applications (Di Ciaccio, Cramarossa and Fatica, 2018). It comprises the upstream and downstream segments. While the upstream segment covers the activities leading to the development of the space infrastructure, including research and development and satellite production, the downstream segment utilises the research and technology of the upstream to develop innovative space services and applications (Di Ciaccio, Cramarossa and Fatica, 2018; de Concini and Toth, 2019).

In recent decades, technological advances and commercial breakthroughs changed business models and actors in the Space Economy, marking the shift from the Old Space Economy to the New Space Economy. New entrants in the space industry and their competition reduced production costs, accelerated production lines, and introduced technological innovations and new business opportunities. Under the impetus of these changes, the space sector started to have a profound impact on the global economy. In the European Union, the downstream segment of the Space Economy created one million jobs, directly and indirectly, so producing 50 billion in gross value added yearly (Moranta, 2022). Similarly, NASA stimulates economic activities in the United States and contributes to productivity growth by funding R&D activities and establishing contracts with companies and academic institutions (Highfill and MacDonald, 2022). These facts led to a growing interest in the New Space Economy.

The interest in the space business gained momentum with the entry of some famous and successful entrepreneurs in the sector, who created new prospects for space exploration and tourism that were previously seen in science fiction films only. These thriving prospects prompted the emergence of new companies and attracted huge investments. However, this growth also raised concerns about the sustainability of companies' business models and the adequacy of the regulatory framework for the new players and business activities in the New Space Economy.

This chapter is organised as follows. Section 2.2 traces the space industry evolution and the transition from the Old Space Economy to the New Space Economy, highlighting the elements that differentiate them. Section 2.3 analyses the business opportunities and growth prospects coming from the New Space Economy and identifies the leading companies operating in it. Section 2.4 discusses how the regulatory framework has been evolving in the space industry.

2.2. The space industry: from the Old Space Economy to the New Space Economy

The space industry is «the collection of productive activities run by space units, [...] supplying space products either to final users or to other space units» (Graziola, 2018, p. 1). For several years, space units were only governmental, such as national space agencies (e.g., National Aeronautics and Space Administration), defence agencies, and military services (Barbaroux, 2016). The space industry «was enabled by, and grew because of, the institutional customers, not commercial market forces» (Hiriart and Saleh, 2010, p. 54). Its inception dates back to 1957, and Barbaroux (2016) identified three stages of its evolution: centralised, decentralised, and distributed.

The centralised stage of the space industry went from 1957 to 1975 and was characterised by the central control of governments and major industry groups over space activities and transactions. Space activities were developed on political grounds as a strategic and prestigious practice. State actors engaged in space programmes for military and security purposes, economic development, and to enhance the nation's international status (Whitney, 2000; Paikowsky, 2017). In 1958, NASA was established as the agency conducting the USA space programmes. During the Cold War, the US government promoted the race to the Moon by investing a significant amount of resources and money (Hanson and Rosston, 2018; Sanna, 2021). Therefore, commercial and profit rationale was not the primary driver shaping the

dynamics and structure of space industries (Barbaroux, 2016). These traits characterise the Old Space Economy, which was mainly a state-only playground (Paikowsky, 2017).

The decentralised stage was driven by technological advances that reduced the costs of accessing satellite communication services and enabled the diffusion and commoditisation of goods and services, along with the advances in miniaturisation of payloads (Petroni and Santini, 2012). These advances led to the beginning of commercial activities (e.g., mobile telephony, broadcasting), the creation of multinational organisations for the commercialisation of space assets (e.g., Eutelsat, INSAT), and required the adjustment of regulatory and policy frameworks in the space sector (Whitney, 2000; Barbaroux, 2016). However, national bodies and international organisations remained the leading players in the space industry and discouraged private investment. In particular, NASA, which heavily invested in the Space Shuttle program in the 1970s and 1980s, has been accused of intentionally hindering competition from private companies (Autry, 2018).

This scenario radically changed in the early 1990s during the distributed stage in which commercial purposes played a leading role in the space industry, while government entities and private companies pooled their resources and capabilities (Hiriart and Saleh, 2010; Barbaroux, 2016). After the end of the Cold War, the public space budgets declined and, in contrast to the previous stage, state actors encouraged the development of new private space companies through commercial incentives and regulations (Kim, 2018; Denis *et al.*, 2020). After incurring huge costs and two tragic accidents in 1986 and 2003, NASA decided to end the Shuttle Programme and favoured the entry of private entities, which changed the centralised management policy of space activities (Sanna, 2021). This stage, thus, marked the “democratisation of space” and the dawn of the New Space Economy (Denis *et al.*, 2020).

The New Space Economy is «a global trend encompassing an emerging investment philosophy and a series of technological advancements leading to the development of a private space industry largely driven by commercial motivations» (de Concini and Toth, 2019, p. 7). Specifically, it is «the emergence of a different ethos for space where the established aerospace methods and business have been challenged by the more entrepreneurial private sector by adopting more agile approaches and exploiting the latest commercial-off-the-shelf technologies» (Sweeting, 2018, p. 344). The New Space Economy is, therefore, a paradigm shift in the history of the space sector, marking the transition from the space race between countries to the space race between billionaires (Di Ciaccio, Cramarossa and Fatica, 2018; Hsu and Siggelkow, 2019). The New Space Economy encompasses «a long value added chain,

starting with research and development actors and manufacturers of space hardware and ending with the providers of space-enabled products and services to final users» (OECD, 2007) involving public and private actors (Chengzhi, 2011). The term is used to indicate «a community of relatively new aerospace companies working to develop low-cost access to space or spaceflight technologies and advocates of low-cost spaceflight technology and policy» (Frischauf *et al.*, 2018, p.135).

The New Space Economy originated in the United States, where the military-industrial complex needed to turn into an economic and political asset in the context of the post-Cold War era (Autry, 2018; Frischauf *et al.*, 2018; Denis *et al.*, 2020). The federal state supported the outsourcing and privatisation of a part of manned space flights, while also distributing funds to stimulate private-sector interest in providing commercial space transportation capacity (Barbaroux, 2016; Denis *et al.*, 2020). The aim was to reduce the costs of access to space through market competition (Kim, 2018). In this vein, in 2006, NASA announced the “Commercial Crew and Cargo” programme to finance the development of vehicles for commercial space transportation services by private companies promising a recurring supply contract (Barbaroux, 2016; Autry, 2018). Thereby, private companies bore the costs of due diligence on the technical and economic feasibility of the proposed systems, while NASA earmarked \$500 million and selected six proposals from the 24 received, including those from Space Exploration Technologies Corporation (SpaceX) and Boeing (Autry, 2018; Weinzierl, 2018). While Boeing is a historic US aircraft manufacturer for both civil and military use, SpaceX is an American aerospace and space transportation company founded in 2002 by Elon Musk that introduced innovations in the fields of vertical landing and reusability. The European space industry also reduced public space funding and favoured commercialisation and transnational and transatlantic alliances (Peeters, 2002). These changes marked a radical innovation in government procurement, paving the way for public-private partnership programmes that stimulate activity and innovation in the space sector (Weinzierl, 2018).

Several elements distinguish the New Space Economy from the Old Space Economy. First, the stages of the space industry in which the Old and New Space economies developed are different. While the former refers to the centralised and decentralised stages from the 1950s to the end of the 1980s, the New Space Economy was born in a different context, shaped by the distributed stage in the early 1990s. These different contexts are shaped by different actors and activities. National space agencies, defence agencies and international organisations, which were the main actors and customers of space activities in the Old Space Economy, are now joined by non-traditional space actors in realising products and services in both upstream and

downstream segments. Security and military services are no longer the main space activities. In the New Space Economy, private companies and start-ups implement new business models by exploiting new applications and commercial services. Thus, national security, military strategies and prestige considerations are replaced by economic growth, technological development, and exploration rationale.

Furthermore, in management’s terms, the Old Space Economy was characterised by central control of State actors over space activities, which were used to compete with other States. In the New Space Economy, space activities are carried out through collaboration between public and private entities. In particular, private actors, through new and different research and development and financing models, compete with each other to provide commercial services to private and public customers (Paikowsky, 2017; Frischauf *et al.*, 2018; Pomeroy, Calzada-Diaz and Bielicki, 2019). Finally, whereas space activities were exclusively financed by public investments in the Old Space Economy, in the New Space Economy, public funds have drastically reduced, and space activities and programmes are mainly funded by private investments. Table 1 summarises the elements distinguishing the Old Space Economy and the New Space Economy.

Table 1 - Differences between the Old Space Economy and the New Space Economy (Source: author’s elaboration).

	Old Space Economy	New Space Economy
<i>Space industry stage</i>	Centralised and decentralised	Distributed
<i>Space actors</i>	National space agencies Defence agencies International organisations	National space agencies Private companies Start-up
<i>Space activities</i>	Security and military services	Commercial services
<i>Rationale</i>	National security, military strategies and prestige considerations	Economic growth, technological development, exploration
<i>Management</i>	State actors controlled and managed all space activities	Collaborations between public and private entities
<i>Competition</i>	Competition among Nations	Market competition among private companies
<i>Customers</i>	National space agencies, defence acquisition agencies, military services	Private customers, States
<i>Funds</i>	Public investments	Private investments

2.3. Business opportunities in the New Space Economy

The New Space Economy opened up various business opportunities for companies traditionally operating in the space sector, companies that diversified their business by having the necessary skills and resources for space activities, and start-ups. This section analyses the market segments and companies operating in the New Space Economy. It also highlights investment trends by public and private players and the turnover generated and expected in the coming years.

Traditionally, private companies operating in the space sector are distinguished into: “space access” companies that focus on launching people and payloads into space; “remote sensing” companies that provide images of the Earth and are linked to satellite data and analytics companies; “habitats and space stations” companies that plan the safe provision of facilities for manufacturing, research and tourism activities; and “Beyond Low Earth Orbit” companies that range from manufacturing in space to materials extraction and the colonisation of Mars and the Moon (Weinzierl, 2018).

The services, technologies and approaches within the Information Technology (IT) sector were transferred to the space sector, revolutionising downstream space applications and the entire space sector value chain (Di Ciaccio, Cramarossa and Fatica, 2018). Furthermore, the success of the first movers, like SpaceX, encouraged investors and companies to define new business models and new commercial fields in both upstream and downstream segments (Frischauf *et al.*, 2018). Table 2 summarises the market segments and their activities in both Space Economy segments and offers an overview of some companies’ activities in these markets.

The **upstream segment** comprises «all activities that focus on the design, manufacture, assembly, launch, functioning, maintenance, monitoring and repair of spacecraft destined to be sent out to space as well as the products and services related to them» (Strada and Sasanelli, 2018, p. 10). They can be grouped into three market segments, namely manufacturing, launch services, and ground equipment, which account for 11% of the total market value (Euroconsult, 2021).

Table 2 - Space activities in the upstream and downstream segments (Source: author's elaboration).

Space Economy segments	Market segments	Main activities	Main companies
Upstream segment	<i>Manufacturing</i>	Design and manufacture of satellites and associated components and subsystems	Boeing Lockheed Martin Made In Space Orbital ATK (acquired by Northrop Grumman Innovation Systems in 2018) Raytheon Technologies
	<i>Launch services</i>	Develop launch vehicles and facilities	Arianespace Blue Origin SpaceX Stratolaunch Systems
	<i>Ground Equipment</i>	Manufacturing of hardware and software for mission control centres, GNSS receivers, communication terminals, gateways, control stations, VSATs and DBS dishes, and other equipment	Intelsat ND Satcom Terma ViaSat
Downstream segment	<i>Satellite services</i>	Satellite communications, Earth observations and imaging constellations	Maxar Technologies OneWeb SES Skybox Imaging (acquired by Planet in 2017)
	<i>National security</i>	Launch of missiles, nuclear explosions, providing resistant communications for strategic and tactical forces during a conflict	Airbus Defence and Space Boeing Lockheed Martin
	<i>Resources mining</i>	Extraction of resources and materials	Asteroid Mining Corporation Deep Space Industries (acquired by Bradford Space In 2018) inspace Moon Express
	<i>Human suborbital spaceflight</i>	Space tourism and crew training	Blue Origin Orion Span SpaceX Virgin Galactic XCOR (closed in 2017)