

Beyond the planetary boundaries: exploring pluralistic accountability in the new space age

Exploring the
new space age

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Patrizia Di Tullio, Matteo La Torre and Michele Antonio Rea
*Department of Economic Studies, University "G. d' Annunzio" of Chieti-Pescara,
Pescara, Italy*

James Guthrie
*Department of Accounting and Corporate Governance, Macquarie University,
Sydney, Australia and
Knowledge Research Pty Ltd, Sydney, Australia, and*

John Dumay
*Department of Accounting and Corporate Governance, Macquarie University,
Sydney, Australia*

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Abstract

Purpose – New Space activities offer benefits for human progress and life beyond the Earth. However, there is a risk that the New Space Economy may develop according to an anthropocentric mindset favouring human progress and survival at the expense of all other species and the environment. This mindset raises concerns over the social and environmental impacts of space activities and the accountability of space actors. This research article explores the accountability of space actors by presenting a pluralistic accountability framework to understand, inspire and change accountability in the New Space Economy. This study also identifies future research opportunities.

Design/methodology/approach – This paper is a reflective and normative essay. The arguments are developed using contemporary multidisciplinary academic literature, publicly available evidence and examples. Further, the authors use Dillard and Vinnari's accountability framework to examine a pluralistic accountability system for space businesses.

Findings – The New Space Economy requires public and private entities to embrace hybrid and pluralistic accountability for their social and environmental impacts. A new way of seeing the relationship between human life, the Earth and celestial space is needed. Accounting language is used to mirror and mobilise broader forms of responsibility in those involved in space.

Originality/value – This paper responds to the AAAJ's special issue call for examining how accountability can be ensured in the New Space Age. The space activities businesses conduct, and the anthropocentric view inspiring their race toward space is concerning. Hence, the authors advocate the need for rethinking accountability between humans and nature. The paper contributes to fostering the debate on social and environmental accounting and the accountability of space actors in the New Space Economy. To this end, the authors use a pluralistic accountability framework to help understand how the New Space Economy can face the risks emanating from its anthropocentric mindset.

Keywords Space economy, New space age, Accountability, Collaborative business model, Hybrid organisations, Anthropocene

Paper type Research paper

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1. Introduction

This article is a reflective and normative essay. It provides food for thought on possible future research into the social and environmental impacts of space activities and corporate accountability in New Space Age businesses (Russell and Vinsel, 2017; Witze, 2018; Spector and Higham, 2019). This essay was written specifically for the AAAJ special issue, “Accounting for the New Space Age,” which calls for papers that shed insights into how we can ensure greater accountability in space. Our views align with Alewine (2020) in that the space sector must develop accountability practices to foster transparency.

Activity in the New Space Economy creates economic growth, helps develop innovations and technologies applicable to non-space sectors, and gives competitiveness and prestige to nations and companies (Vittori *et al.*, 2022). The interests at stake in these hazardous and costly activities are economic, strategic and geopolitical (CSIS Aerospace, 2020). Accordingly, because government space agencies and private space companies need to protect national security, maintain security in space, sustain military advantage, or preserve their competitive edge, they may be reluctant to account for their space activities or publicly disclose information about such matters. Low public accountability is aided by a lack of legislation and regulations requiring public and private companies to disclose their space activities’ economic, social and environmental impacts. Thus, from an accounting and accountability perspective, the New Space Economy presents many challenges that might be solved by modifying established techniques from other areas of accounting. Moreover, although the modifications required may be substantial, those reforms might help us adapt to some unique quandaries with the New Space Economy, such as physical constraints, supply chain complexity and waste management (Wooten and Tang, 2018; Alewine, 2020).

The advent of the New Space Economy is a “paradigm shift” (Di Ciaccio *et al.*, 2018, p. 255). Denis *et al.* (2020, p. 434) define it as the “democratisation of space” because outer space has become accessible not only to global superpowers but also to non-space actors, such as private companies, start-ups, research centres and universities (Dahl, 2019; Kim, 2019). In this contest, the resources of both governments and private companies are being combined for efficiency, and the traditional boundaries of private and public entities, and their business models, are being radically altered. The collaborative business model concept emphasises how governments and private companies cooperate to create value in the New Space Economy. However, these models also reveal the need for accountability in these enterprises’ value-creation processes (Rohrbeck *et al.*, 2013).

For example, Ax-1, the first entirely private astronaut mission to the International Space Station, was realised and managed through a collaborative project. Ax-1 was privately financed by Axiom and used a SpaceX spacecraft, proving space is no longer the realm of publicly-funded nationalistic adventures (Gohd, 2022). As such, this mission ushered in a New Space Age. Today, space-based commercial activities, such as tourism, are becoming viable business models, with three of Ax-1’s four astronauts paying about US\$55 million each for the ride to the space station. At this price tag, however, these new business activities are not within the economic reach of all people. In this sense, democratising space does not imply that all stakeholders can participate. Still, it does broaden the pool of organisations conducting activities there. Notably, Ax-1 was not just a touristic joyride. During their ten-day journey, the astronauts conducted numerous scientific experiments and commercial activities (Gohd, 2022). But at what cost to Earth’s people and the environment? We are plagued with the relentless advance of climate change, COVID-19 and social inequities. Are commercial space activities helping these problems? Or are they making them worse?

The rapid pace of business development, significant business turnover of US\$370 billion globally in 2021 (Euroconsult, 2022), and the growing interest of billionaires in the New Space Economy (e.g. Elon Musk with SpaceX and Jeff Bezos with Blue Origin), raises questions over the social and environmental consequences of New Space businesses. These enterprises must

be held to account for their impact on people and the environment. Further, like any other human and business activity, we can see the New Space Age inspired by an anthropocentric view that sees humans at the centre of the universe (Gray and Milne, 2018). However, the New Space Age puts these concerns at the forefront.

One concern concerns the ambitious vision of human activity extending beyond the Earth and toward space. Several space entrepreneurs claim that space activities will solve many social and environmental problems and benefit humanity (Spector and Higham, 2019). In particular, missions to explore and make other planets like Mars habitable and space tourism are often motivated by humankind's survival imperative. The goal of solving environmental problems and preserving our species drives space colonisation activities (Szocik, 2021). According to Elon Musk, "The future of humanity is fundamentally going to bifurcate along with one of two directions: Either we are going to become a multiplanet species and a spacefaring civilization, or we are going to be stuck on one planet until some eventual extinction event" (Drake, 2016). Thus, there is a great interest in deepening space actors' accountability because the social and environmental responsibility is more profound than that facing any other economic sector. Moreover, the rationale behind the New Space Economy raises concerns about Earth's environmental survival. This makes the New Space Economy's accountability different from the other sectors. This is what is investigated in this paper.

Unlike other sectors, activities in the New Space Economy also impact the environment outside our planetary boundaries. Further, embryos and non-human living beings, such as animals and plants, are being used to transform outer space into human territory (Damjanov, 2018), leading us to examine how human actions are influencing the nature and functioning of the Earth's systems (Rockström *et al.*, 2009; Bebbington *et al.*, 2019). It also demands that we explore the implications of the New Space Age for accountability because human existence beyond the Earth is no longer science fiction; it is a reality and fast becoming a big business with more profound accountability issues.

This paper further explains how accounting practices can develop within the New Space Age. The aim is to promote greater accountability in businesses to ensure that humans take responsibility for the future of life on this planet – both human and non-human (Alberts, 2011; Newman and Williamson, 2018). As such, we examine the accountability system in the New Space Economy using Dillard and Vinnari's (2019) accountability framework. Additionally, we critique the anthropocentric view that is inspiring the New Space Economy. Thus, we reflect on social and environmental accountability within space businesses in the New Space Age and trace avenues for future research.

2. Background

2.1 *The New Space Economy and accountability in hybrid organisations*

The space economy is "the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilising space" (OECD, 2011). Space activities and projects have been the prerogative of the public sector for decades. Historically, government agencies, like the European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA), along with military organisations, like the US Air Force, have been responsible for R&D and constructing infrastructure when it comes to matters of space. Moreover, they have used these activities to show power, leadership and international prestige (Martin and Beaudry, 2015; Barbaroux, 2016). In the mid-1960s, NASA's annual budget reached \$7 billion, around 0.7% of the US GDP (Weinzierl, 2018), while the Soviet Union invested more than \$5 billion over the same period (CIA, 1998). However, the need to restrict public expenditure and total debt has led to a radical reduction in the R&D capacity of many space-faring governments (Broadbent and Laughlin, 1999; Forrer *et al.*, 2010). For example, the budgets of

the US and Russian space agencies have steadily declined to around 0.1% of GDP and \$700 million, respectively (Weinzierl, 2018; Moltz, 2019).

After the Cold War era, the United States supported the development of a private space sector to restructure the US military industry (Denis *et al.*, 2020). Starting from the late 1990s, the term “New Space” emerged in the United States. Space activities attracted investment from visionary entrepreneurs, such as Elon Musk. These new and innovative start-ups significantly changed the space sector and marked the rise of the New Space Economy (Nakahodo and Gonzalez, 2020). Sweeting (2018, p. 344) defines the New Space Economy as “the emergence of a different ethos for space where the established aerospace methods and business have been challenged by the more entrepreneurial private sector adopting more agile approaches and exploiting the latest commercial-off-the-shelf technologies.”

Accordingly, within the New Space Age, the New Space Economy refers to “the economy that builds, operates, exchanges, and finances assets that improve or use the functional value of space exploration, discovery, and commercialisation” (Cahan *et al.*, 2018, p. 1). Now space activity comprises “upstream” and “downstream” segments. The upstream segment comprises traditional space activities, such as manufacturing, launch services and ground equipment. The downstream segment is the upstream segment’s symmetric complement, involving profit-seeking space activities, such as satellite services, national security, resource mining and human suborbital spaceflight (OECD, 2004; Di Ciaccio *et al.*, 2018).

New Space activities typically require a set of resources and knowledge that are too expensive and technologically advanced to be owned by a single organisation. Thus, in the New Space Age, government and private companies share resources and tasks to pursue a common goal through hybrid organisations (Di Ciaccio *et al.*, 2018). Public and private entities have collaborated since the Roman Empire (Hodge and Greve, 2007; Forrer *et al.*, 2010). Nevertheless, these collaborations’ salience, scale, frequency and complexity have recently increased (Villani *et al.*, 2017). These hybrid forms of collaboration have given rise to a third way of thinking where “the private sector could be used to provide public services in the context of partnership” (Broadbent and Guthrie, 2008, p. 149). Indeed, in hybrid organisations, each partner “fills a gap in [the] skill[s], resources, and competencies of [the] other partners” (Villani *et al.*, 2017, p. 879). However, partnerships between public and private organisations have often been subject to accounting and accountability problems that have undermined the principles of transparency, public trust and participation (Baker, 2003; English, 2005; Bloomfield, 2006).

Several missions in the New Space Age have resulted from collaborations between public and private actors, but not all have been successful. For example, the Galileo Program was described as a new form of collaboration for space where the ESA and the European Union (EU) assured support for its public benefits, while the private sector was to bear two-thirds of the costs (Veclani *et al.*, 2011). However, the private investments were based on unrealistic forecasts of high financial revenues. At the same time, the governance structure was characterised by weak lines of responsibility and conflicting roles for the individual actors (Veclani *et al.*, 2011). As a result, the Galileo Program ultimately became fully financed, owned and managed by the EU and the ESA. This case teaches us that public-private partnerships can work, provided that clear and realistic business plans and models can be developed from the outset.

Developing accounting tools for hybrid partnerships can be complex and challenging as each organisation may have specific accounting practices and accountability systems, neither of which may fit the needs of the whole in isolation (Bardach and Lesser, 1996; Bryson *et al.*, 2006; Rajala and Kokko, 2021). As another example, the European Data Relay System (EDRS) was a successful collaboration between the ESA and Airbus (Calzolaio *et al.*, 2020). This project aimed to “provide a data relay service to low-Earth-orbit satellites from geostationary orbit using optical and radio-frequency bands” (Calzolaio *et al.*, 2020, p. 537).

Currently, data relay satellites are placed in geostationary orbit, contributing to a fast, reliable, uninterrupted telecommunication network (ESA) [1]. The project is explained as follows:

Airbus builds, owns, operates and co-finances the system's infrastructure. Airbus also implements and provides the data transmission services to ESA and customers worldwide. ESA funds the infrastructure development. The European Commission is the anchor customer through the Copernicus Sentinel satellite missions (ESA, 2014).

Little information about the EDRS initiative's public benefits or societal costs was disclosed. The mission was treated as a private concern, and any involvement of public goods was not considered. However, more transparency would have allowed us to assess the impact of these business activities on society. That said, it is worth acknowledging that transparency can be hampered by commercial confidentiality and the need to protect sensitive data (De la Roche, 2011; Willems and Van Dooren, 2011; Economic and Security Committee - Bockel, 2018; Rajala and Kokko, 2021). However, providing information for external accountability does not necessarily mean that sensitive information needs to be divulged (Chrysaki, 2020). Instead, businesses need to understand the demand for accountability by society and furnish sufficient information to fulfil that demand (Dillard and Vinnari, 2019). Thus, the accountability challenge in hybrid partnerships is to respond to and balance two different logics of accountability: the public one, which is more democratic and oriented to broader society and its judgement, and the private/commercial one, which is profit-oriented and more concerned with a narrow set of stakeholders' interests (Mulgan, 2000; Grossi *et al.*, 2021). Making this distinction requires the use of different techniques of accountability and balancing the trade-off between public good and private wealth.

Commercial space activities are now a reality with a promising future that arguably benefits human progress and extends life beyond the Earth (Alewine, 2020). Space services and technologies offer unique opportunities to support the Sustainable Development Goals and understand, assess and manage issues related to climate change, disaster management and sustainable development in general (United Nations, 2018; Baumgart *et al.*, 2021). Satellites are the cornerstone of space activities – they are “the lifeblood of the entire space industry” (Hiriart and Saleh, 2010, p. 53). The data generated by Earth observation satellites benefit weather and natural disaster forecasting, climate monitoring, and agrifood system management. These data are also helping scientists to counter climate change and its effects (Borowitz, 2016; Di Ciccio *et al.*, 2018; Denis *et al.*, 2020). Satellite signals also support GPS devices and location-based services and improve safety by helping to prevent collisions between vehicles, such as trains, and informing responses to natural disasters such as oil spills and forest fires (Canis, 2016; Deloitte, 2019). Similarly, satellites extend Internet access to many world regions, reducing the digital divide (Bacsardi *et al.*, 2017; Strada, 2018).

Another social benefit from space activity comes with the idea that we might be able to exploit extra-terrestrial raw materials and energy resources (Crawford, 2016; Friel, 2019). The Solar System is rich in energy and material resources. Metals such as platinum, palladium and rhodium can be found on near-Earth objects. Mars holds the elements necessary to make plastics and several gasses (Wilson, 2008; Entrena Utrilla and Welch, 2017; Denis *et al.*, 2020). Using these resources may help us reduce the number of natural resources we extract and consume from the Earth and help us respect the environmental limits within which we can safely operate (Rockström *et al.*, 2009; Steffen *et al.*, 2011). The planetary boundaries approach, put forward by Rockström *et al.* (2009), is a new approach to global sustainability that predicts severe risks from manipulating the Earth's natural systems. The boundaries are quantitative “human-determined values of the control variable set at a safe distance from a dangerous level” (Rockström *et al.*, 2009, p. 34). According to Rockström *et al.* (2009), crossing the nine defined planetary boundaries will result in a human-induced environmental change

on a global scale. Thus, some aspects of space exploration are motivated by the aim of mitigating these risks and avoiding catastrophic environmental changes. However, an anthropocentric view of the New Space Economy eclipses these positive implications of space activities and exploration risk.

2.2 The anthropocentric view of the New Space Economy

Over the last few decades, changing stakeholder demands have been undeniably driven by a renewed view that corporations and humans should be held accountable for their social and environmental impacts (Gray *et al.*, 1988, 2014). However, for a longer time, human social life and the relationship between corporations and society have been grounded on a view that sees humankind and humanity at the centre of the universe. From this perspective, humanity is a geophysical force that will destroy and is destroying habitats and species to grow and prosper (Steffen *et al.*, 2007). For many, this alienation of man from nature will cause our future extinction (Steffen *et al.*, 2007; Rockström *et al.*, 2009; Gray and Milne, 2018).

The Anthropocene is the geological epoch that replaced the Holocene and reconceptualised the relationship between humans and nature (Gren and Huijbens, 2014; Baskin, 2015). The Anthropocene “relates to the nature and functioning of the Earth system and the role of human actions in driving those dynamics” (Bebbington *et al.*, 2019, p. 155), while the Holocene is the inter-glacial geological epoch characterised by a stable climate supporting the modern human species (Steffen *et al.*, 2007; Gren and Huijbens, 2014). As humanity has advanced with its activities, it has transformed and compromised the Holocene epoch’s biophysical conditions, marking a point of no return (Castree, 2014). In this era, humans are geological agents who “place its very continuation and the continuation of many other species under question by virtue of its success” (Alberts, 2011, p. 6). The impacts of humans on the planet include altering biogeochemical cycles, modifying terrestrial water cycles and driving extinction rates (Steffen *et al.*, 2011; Baskin, 2015). Therefore, the Anthropocene brings the sustainable development debate to a new phase where “human action is a driver of global environmental change” (Rockström *et al.*, 2009, p. 472), and the interrelation between humans and nature should be re-evaluated (Alberts, 2011; Gren and Huijbens, 2014). However, in an anthropocentric approach, we would be wise to rethink the accountability of human beings and corporations (Bebbington and Larrinaga, 2014; Bebbington *et al.*, 2019; Cho *et al.*, 2021).

By reflecting on the current relationship between nature and humanity, Gray and Milne (2018, p. 828) question “whether we want the future of Earth to turn entirely on humans.” This question makes us consider what will happen if human life crosses planetary boundaries. It asks us to consider the mindset that drives space activities and exploration. Our vision of humankind in the New Space Age appears inspired by an anthropocentric mindset. The Anthropocene mindset focuses on how human actions change and influence the nature and functioning of the Earth’s systems (Rockström *et al.*, 2009; Bebbington *et al.*, 2019). However, if we take an anthropocentric approach, we would be wise to rethink the accountability of human beings and corporations (Bebbington and Larrinaga, 2014; Bebbington *et al.*, 2019; Cho *et al.*, 2021).

The debate about accountability in Anthropocene is spreading the awareness that, as Bebbington *et al.* (2019) point out, new forms of account can emerge to reflect the evolving corporate responsibilities in the Anthropocene, and new conceptual artefacts will come up in accounting research and practices. The Anthropocene concept represents a paradigm shift that calls for an “ecological turn” in accounting studies and offers an opportunity to reflect on and articulate the responsibilities that arise from the interactions between humans, corporations and nature (Bebbington and Larrinaga, 2014; Baskin, 2015; Bebbington *et al.*, 2019). The recent advances in space exploration and exploitation call for us to reconsider what corporations and humans are, or should be, accountable for. They cause us to examine

how accountability can be ensured (Tucker and Alewine, 2021, 2022). Thus, in the next section, we examine the dynamics and constituent elements of the accountability systems in space businesses at a conceptual and practical level. The intention is to rethink how a renewed view of accountability might inspire and reshape their accounting practices and social and environmental accountability.

3. Rethinking hybrid and pluralistic accountability for the New Space Economy

Accountability “is a complex and chameleon-like term” (Mulgan, 2000, p. 555). Its definition depends on “ideologies, motifs and [the] language of our times” (Sinclair, 1995, p. 221). In this study, we adopt the definition of accountability as “a relationship in which people are required to explain and take responsibility for their actions” (Sinclair, 1995, p. 220). Specifically, the relationship is “between an actor and a forum, in which the actor should explain and justify his or her conduct, the forum can pose questions and pass judgement, and the actor may face the consequences” (Bovens, 2007, p. 450). Thus, the main feature of external accountability is that it involves social interactions and exchanges and implies the right to authority (Mulgan, 2000).

Accountability is a “golden concept” used to “convey an image of transparency and trustworthiness” (Bovens, 2007, p. 448). Transparency can be a very effective antidote to secrecy and improve accountability in some contexts (O’Neill, 2006; Ferry and Eckersley, 2015). However, in others, it “can result in organisations taking a box-ticking approach to publishing a huge volume of raw data rather than meaningful information” (Ferry *et al.*, 2015, p. 350). Transparency contains conflicting potentials since it promises and threatens to reveal or uncover information and, in this sense, may even weaken the effectiveness of accountability (Roberts, 2009). Thus, accountability cannot result in total transparency. It is an unattainable ideal.

A counterpart to many of the shortcomings of transparency can be *intelligent accountability*, which involves active and prolonged investigation over time. Through listening, questioning and dialogue, an attempt is made to make communication less deskilled (Roberts, 2009). This makes it possible to not focus on periodic snapshots but, rather, to assess commitments against results, which, in turn, makes it less easy to manipulate results (Roberts, 2009). Thus, despite its multifaced meanings and nuance, accountability should be based on a dialogue in which the burden of finding compromises between different interests should fall on all parties involved. This requires relationships between actors, and in the most complex ones, activating this dialogue should lead to including others in the decision-making process and sharing the responsibility for the results (Messner, 2009).

In the collaboration between public and private entities, accountability includes relationships between more than one actor and the forum. Further, these collaborations “use resources, governance structures and logics derived from different sectors with divergent aims and actors” (Grossi *et al.*, 2021, p. 578). However, the accountability logic is different in public and private organisations. Public sector organisations should serve the national community (Parker and Gould, 1999). Their accountability “concerns the relationship between politicians and citizens as well as to that between politicians and public managers” (Almquist *et al.*, 2013, p. 480). In the private sector, accountability mainly means being responsible to shareholders who can demand information about the company’s financial performance. In hybrid organisations, different stakeholders have different demands, so those held accountable must speak in “several languages at the same time” (Messner, 2009, p. 919). Thus, the accountability dynamics in a collaboration between public and private entities can become very complex.

This complexity is particularly characteristic of public-private space collaborations in the New Space Economy. Previously, governments have tended to operate in the space sector

with non-financial objectives. However, partnering with private companies has introduced new commercial, financial and profit-seeking objectives (Tucker and Alewine, 2021). As Villani *et al.* (2017) state, the success of hybrid forms of collaboration also depends on the business model they adopt and how those models integrate different institutional logics and combine resources and competencies. Traditional business models cannot clearly show how partners collaborate to create value (Lund and Nielsen, 2014). Conversely, the collaborative business model emphasises such cooperation between partners. For this reason, it may be a suitable model for explaining how New Space businesses operate.

At the core of the collaborative business model sits the idea that partners compensate for their weaknesses by exploiting each other's skills, expertise and resources. In a collaborative business model, organisations that might differ in type or their position in the value chain work together to form a value creation system (Rohrbeck *et al.*, 2013). Opting for a collaborative business model is particularly appropriate when the expertise needed to compete in a new market cannot be found in-house but is the strength of one's partner (Lindgren *et al.*, 2010). Collaborative business models might also satisfy public and private stakeholders' information needs as this model provides a framework for identifying broader accountability dynamics among the multiple actors involved in value creation. For example, a collaborative business model could be a graphical representation of space activities that helps to visualise and distinguish who is responsible for what in a hybrid organisation (Rohrbeck *et al.*, 2013).

However, collaborative business models cannot solve all the accounting and accountability issues of the New Space Economy. For example, not much information on the activities being conducted in space is available, and the methods for creating, acquiring, organising and reporting space information are underdeveloped (Di Tullio, 2022). This lack of information is combined with outdated regulatory frameworks (Tucker and Alewine, 2021) that are inadequate for meeting innovation challenges (Fenwick *et al.*, 2017). So, like many sectors in recent decades where innovation has spread rapidly (e.g. artificial intelligence, driverless cars), regulators are struggling to keep up. In the case of the space sector, current international space law comes from the 1967 Outer Space Treaty, which does not cover many aspects of the New Space Economy, such as non-government actors, commercial activities, space tourism, and social and environmental issues, for example, managing space debris (Toivonen, 2022).

Furthermore, in the case of the New Space Economy, there is a lack of adequate mechanisms to hold companies accountable for the impact of their activities on the global commons (Wooten and Tang, 2018; Ayetey, 2020; Freeland and Ireland-Piper, 2022). Scholars have emphasised several challenges in ensuring accountability in hybrid organisations and have called for new solutions (Rajala and Kokko, 2021). However, the characteristics of, and multiple interests within, the New Space Economy will make these problems even more complex.

3.1 A pluralistic accountability framework

We analyse the accountability system in the New Space Economy. The idea is to rethink pluralistic accountability in space businesses and reflect on the characteristics of hybrid organisations in the sector. Dillard and Vinnari (2019) argue that accountability should be the primary objective of an accounting system – an accounting system being “a body of rules and resources which are drawn upon in the practice of accounting” (Roberts and Scapens, 1985, p. 447). Traditionally, accounting systems have privileged the needs of shareholders (Holmgren Caicedo *et al.*, 2019). However, this accountability system “eclipses broader questions of accountability” (Power and Laughlin, 1992, p. 133).

An accountability system might be synthesised as: “A accounts to B, for K acts, based on X standards, through Y procedures, at time Z, subject to Q consequences” (Dillard and Vinnari, 2019). However, given the hybrid partnerships in the New Space Economy, accountability

systems must be designed around stakeholder needs, norms and values. Additionally, these systems need to move from being accounting-based to being accountability-based. Dillard and Vinnari (2019) proposed a framework for studying and designing pluralistic accountability systems as a lens through which to assess and rethink the accountability dynamics of the New Space sector. Thus, we use Dillard and Vinnari's (2019) accountability framework, which is based on a collaborative business model, to examine and rethink a pluralistic, accountability-based accounting system for the New Space Age.

Dillard and Vinnari's (2019) framework is organised around eight elementary accountability units that further help conceptualise, implement, and evaluate an accountability system. These eight units, specified by Rached (2016), are formality, spatial vectors, institutionality, expertise, substance, procedure, timing, and consequence. Each has a distinct density that can vary between the thicker and thinner ends of a spectrum of possibilities. The thicker and thinner ends imply that power holders will feel bound by the account holder and be involved in more or less complex, institutionalised and formal connections (Rached, 2016). Table 1 lists these units and their definitions and explains how we have applied them to the context of the New Space Economy.

Figure 1 shows how Dillard and Vinnari's (2019) framework can create a pluralistic accountability system in the New Space Economy. The figure shows the eight elementary units (in bold) and their relationships (through the arrows). Combining these elements reflects the characteristics of hybrid organisations in the New Space Economy based on the collaborative business model idea. The framework encapsulates three main points:

- (1) Horizontal spatial vectors, procedures and institutionality shape hybrid accountability in the New Space Economy;
- (2) The power relationship between actors concerns the balance of power between the power holders and the account holders (vertical spatial vectors), where the power balance results from units of expertise and consequences; and

Elementary units	Definition	Application in the new Space economy context
<i>Spatial vectors</i>	... show how the power relationship between two agents materialises along horizontal or vertical lines	I. Hybrid accountability in the New Space Economy (Section 3.1.1)
<i>Procedures</i>	... explain the methods and tools of participation, inquiry and contestation that can influence decision-making	
<i>Institutionality</i>	... identifies whether it is the institution or each of its members who are called to account	
<i>Expertise</i>	... establishes whether the power holder and the account holder have the knowledge to decide based on reputedly objective, impartial, and universal premises	II. Power relationship between actors (Section 3.1.2)
<i>Consequences</i>	... the sanctions imposed on the power holder	III. Regulating accountability-based accounting (3.1.3)
<i>Formality</i>	... the power relationship between the power holder and the account holder. These can be more or less formal and/or more or less regulated	
<i>Substance</i>	... the standards and evaluation criteria that the power holder is held to	
<i>Timing</i>	... the moment the power holder expects a reaction from the account holder, or the moment the latter has the opportunity to respond to the former	

Source(s): Authors' own creation

Table 1.
Elementary units of
accountability systems
in the New Space
Economy

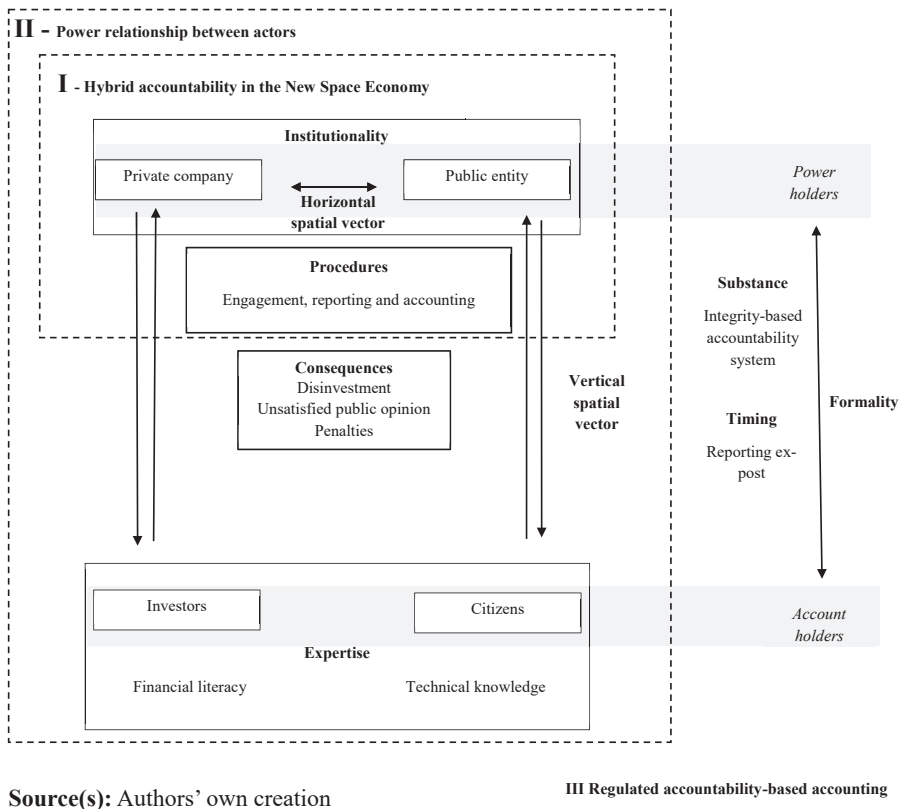


Figure 1.
A framework
conceptualising
pluralistic
accountability in the
New Space Economy

Source(s): Authors' own creation

III Regulated accountability-based accounting

- (3) Accountability-based accounting must be regulated as it depends on formality, substance and timing.

These three points are discussed in more detail next to show how their elements shape the New Space Economy context.

3.1.1 Hybrid accountability in the New Space Economy. Rethinking accountability in the New Space Age means understanding who should be accountable and for what in hybrid collaborations. Three elementary units – horizontal spatial vectors, procedures, and institutionality – help to explain the accountability that characterises hybrid collaborations in the New Space Economy. *Horizontal spatial vectors* refer to relationships between the power holders, that is, the private companies and public entities involved in space operations, that are at the same hierarchical level and subject to mutual control or cooperation (Dillard and Vinnari, 2019). At the same time, they have different legal or moral obligations to account holders, that is, investors and citizens. *Procedures* explain the methods and tools of participation, the inquiry and the contestation that can influence decision-making. *Institutionality* concerns the characteristics of the power holder and whether that entity should be understood in its collective form or through its individual members (Rached, 2016; Dillard and Vinnari, 2019).

Spatial vectors – When managing space activities, collaboration implies a relationship of mutual control and cooperation. Actors involved in hybrid collaborations must ensure the

mutual sharing of information on their activities' costs and social and environmental impacts. At the same time, they need to provide information to their stakeholders by balancing different institutional logic (Villani *et al.*, 2017).

Public entities must maintain political legitimacy, while private companies seek legitimacy from those who buy their products or use their services (Dumay *et al.*, 2010; Shaoul *et al.*, 2012; Rajala and Kokko, 2021). Typically, this means demonstrating responsible and transparent behaviour by reporting information (Argento *et al.*, 2019).

The following excerpt from a newspaper article by Ray (2021) shows that the information revealed by the Securities and Exchange Commission, SpaceX itself, and other unofficial sources have not provided a clear picture of the company's actual value and why it has changed over time:

Elon Musk's privately held rocket company SpaceX raised around \$1.16 billion via equity funding over the last two months per SEC filings, with the company now reportedly being valued at \$74 billion. This compares to a previous valuation of \$46 billion based on a \$2 billion fundraiser last August. So, what has really changed for SpaceX to command a 60% jump in valuation?

The complexity of hybrid organisations makes providing information to different stakeholders difficult and creates a lack of accountability (Argento *et al.*, 2019). Therefore, despite investors, analysts and journalists asking questions like the one in the example, the company and its owners do not need to answer them.

Procedures – Actors of hybrid organisations establish ways of communicating and engaging with account holders. There is no doubt that the spate of recent space missions has caught the public's attention and driven the creation of a global community interested in space science and technology – mainly through social media (Chrysaki, 2020). The companies and agencies involved acknowledge that communicating information about their activities is essential; accordingly, many have been active on Twitter (Bertrand *et al.*, 2015). In the following example, NASA reveals the discovery of four new worlds during the recent TESS mission:

New exoplanets found! Using data from @NASAExoplanets TESS mission, astronomers have identified 4 new worlds beyond our solar system that are in a 'teenage' phase of their life cycle, a little-understood stage of planetary evolution. (NASA Twitter Account, July 12, 2021)

By highlighting its discoveries, it could be said that NASA uses Twitter to legitimise its investments in space missions and make the public feel involved. At the same time, these organisations must report financial and non-financial information to different stakeholder groups. According to Antonini and Larrinaga (2017), the boundaries of reporting should go beyond the principle of financial control and allow all economic, social and environmental impacts for which the company has some degree of responsibility to be included. In this way, organisations can be more accountable for their impacts. Furthermore, powerful environmental groups can be the 'voice' of the natural environment. They can help to give the environment greater visibility and importance, even in managerial considerations, by demanding respect for its limits (Starik, 1995; Laine, 2010). Such discussions may even reassure investors about the risks of their investments.

Institutionality - In hybrid organisations, private companies and public entities take on a common and collective form, becoming a single entity. As such, they are not individually but collectively responsible for their activities. We advocate that this collective responsibility should be realised as social and environmental accountability for the entire space project. Accordingly, the organisation's accounting and reporting system must capture this overall accountability. The actors in hybrid forms of collaboration often lose their identity, retaining a certain level of anonymity, as can happen with stakeholder groups in corporate accountability (Seal and Vincent-Jones, 1997; La Torre *et al.*, 2020). The idea behind the

collaborative business model emphasises that private and public entities should be considered wholly and share the same responsibilities and interests. For example, the considerable expertise of public entities in space operations could be combined with the efficient operational practices of private companies to create sustainable practices in the New Space Economy (Williamson, 2012). In this way, collaborative business models might support the shift from single-actor accountability to hybrid accountability for a space project's whole value-creation process.

3.1.2 The power relationship between actors. The account holders in the New Space Economy are investors and citizens, that is, people interested in the public goods affected by space activities. Their relationship with private companies and public entities (power holders) is vertical. Vertical accountability suggests a hierarchical and asymmetrical power relationship. According to Roberts (1991), in hierarchical forms of accountability, "accounting information appears as just one means of negotiating and defining the significance of events, as a method for expressing and enforcing expectations, and as a resource in the enactment of particular power relations" (p. 355). Thus, theoretically, accounting information and corporate reporting can balance the power relationship between power holders and account holders.

As argued before, power holders can satisfy the account holders' needs and manage their expectations through *procedures*. However, corporate reports, mainly voluntary sustainability reports, have often been criticised for presenting misleading information and representing a company picture that is usually far from a credible and faithful representation of the company's social and environmental impacts. So, these reports are not an ideal response to the demands for accountability and an accurate accounting of the entity's performance (Adams, 2004; Cho *et al.*, 2010; Boiral, 2013). Company reporting practices have longstanding limits in accounting for externalities (Unerman *et al.*, 2018). Meanwhile, over time, critical research on social and environmental accounting has kept providing evidence and arguments that generate scepticism on the ability of social and environmental accounting to promote 'real accountability' without a radical change in capitalist society (Brown and Fraser, 2006; Puroila and Mäkelä, 2019). However, the literature shows that voluntary reporting practices can have a limited influence on rebalancing the power between actors. Furthermore, these power relations can also be influenced and shaped by *expertise* and *consequences*.

Theoretically, expertise establishes whether power holders and account holders can make decisions "based on reputedly objective, impartial and universal premises" (Rached, 2016, p. 329). Accordingly, there are four scenarios: (1) both actors have technocratic expertise; (2) both are lay and non-technical agents; (3) only the power holder has expertise; and (4) only the account holder has expertise. *Consequences* refer to the influence the account holders have and whether they have the power to impose sanctions on the power holder (Dillard and Vinnari, 2019). Sanctions are an example of consequences. They can be hard or soft, direct or indirect (Rached, 2016). Thus, expertise and consequences are the primary units for assessing the power relationship between power holders and account holders in an accountability system (Rached, 2016).

Expertise – The basis of relationships in hybrid organisations are long-term contracts – highly technical documents drawn up by expert consultants with legal, engineering, and accounting training (Bloomfield, 2006). Further, accountants usually have technical expertise (Dillard and Vinnari, 2019). Power and Laughlin (1996, p. 446) state that, theoretically, the problem is always making "internal experts accountable to external stakeholders." However, a mismatch between transparency and accountability can occur when stakeholders lack the necessary skills and experience to interpret and analyse the information organisations disclose (Ferry *et al.*, 2015). For example, corporate reports primarily include accounting values, but most ordinary people are unfamiliar with basic financial principles (Power and

Laughlin, 1996; Poon and Olen, 2015). According to Conrad (2005, p. 6), “accounting information enables the exercise of power by those who have the information, and who hold others accountable on the basis of it.” Therefore, solving this longstanding problem will depend on the actors’ knowledge and expertise.

Likewise, the stakeholders of public entities may be interested in the economic, environmental and social impacts of an agency’s space activities. However, they are not technocrats. An example is testing in the desert – a widespread practice. NASA, for example, tested its Space Launch System in the Utah desert. NASA’s stakeholders may want information about the impact of these tests on biodiversity. Still, they may not have the technical knowledge to understand their operations and the implications of the information they are given. Even at a base level, citizens probably do not know where the Earth’s boundaries are (Rockström *et al.*, 2009). So, how can they even begin to assess the impact of space activities on Earth and whether they will lead to catastrophic environmental change (Chrysaki, 2020)?

According to O’Dwyer *et al.* (2005), sustainability reporting is meaningful if it is founded on accountability and democracy and focuses on all stakeholders’ rights, needs and empowerment regardless of their economic or social relevance. Therefore, despite not having the technical expertise to assess the complex characteristics of a space project, stakeholders should have the right to information on the environmental impacts of space activities, whether the power holder is a public agency, a private company or a private company hybrid organisation. Similarly, investors (and taxpayers) should have the right to information on the financial implications of space undertakings. These demands may affect the power holder’s decisions about whether and how they conduct space activities.

Consequences – Citizens can inflict soft and indirect sanctions on public entities that may result in negative public opinion. Likewise, private companies can suffer stiff and direct sanctions resulting from reduced investor confidence and customer dissatisfaction. That said, in most cases today, citizens have less power than investors. Therefore, it stands to reason that, in hybrid organisations, the power holders will tend to meet the demands of the more powerful investors and dismiss the citizens’ requests (Bebbington *et al.*, 2008). We see this same power imbalance in the New Space Economy (Foust, 2020).

Private and government entities communicate little information about space activities (Sadat and Siegel, 2022). Most of the time, citizens will not have enough power to demand the information they need, especially when it comes to information concerning the environmental and social impacts of space activities. However, without this information, the power holders in the New Space Age are failing to promote the interests of the natural environment. They do not ensure their voice is heard – even if they try to minimise their operations’ impacts. Further, securing this information can require a hard-fought battle, as the below example shows:

Viasat has petitioned the Federal Communications Commission to perform an environmental review of SpaceX’s Starlink broadband constellation, arguing that the satellite system poses environmental hazards in space and on Earth. [...] SpaceX hasn’t formally commented on the Viasat FCC filing. (Foust, 2020)

According to the same source, SpaceX has neither explained nor proved that its satellite system poses no environmental risks. Instead, it has shrugged off the request as a mere anti-competitive gaming tactic (Foust, 2020). Hence, even the economic operators, who have more power than most, may be unable to access sufficient information on how New Space activities are managed.

Regulation can rebalance the power between power holders and account holders by introducing penalties for those who fail to disclose information deemed necessary by the people. However, according to Owen *et al.* (1997), the uneven distribution of information

reflects an uneven distribution of power in a society that can only change through societal change. Both institutional and cultural reforms are likely needed to shift the stubborn status quo (Bebbington and Thy, 1999; Larrinaga *et al.*, 2002).

Institutional reform usually implies a discursive dialogue, new corporate governance structures, stakeholder involvement and the reinforcement of accountability relationships (Owen *et al.*, 1997; Larrinaga *et al.*, 2002). According to Chrysaki (2020), a voluntary code of conduct for the space industry based on some principles of accountability might be a tool for ensuring sustainability in space activities. It could be that both public and private organisations are interested in adopting this code to demonstrate their commitment to the environment and to improve their public image (Chrysaki, 2020). Such reforms, and the additional knowledge disclosed, might empower stakeholders and help to adjust the power balance. However, the asymmetry between public and private entities means that, in hybrid organisations, accounting practices should be based on joint accountability – they should pierce each entity’s boundaries and look at value creation for society. Despite the limitations of both mandatory and voluntary reporting tools in promoting radical change in corporate accountability (La Torre *et al.*, 2018), these tools and guidelines that promote social and environmental accountability are relevant to all those in the industry, more regulated reporting practices can enhance transparency for more pluralistic accountability, while sanctions can dissuade firms from misbehaving (Martinez, 2019).

3.1.3 Regulating accountability-based accounting and integrity-based systems. Accountability exists where a power holder “has the obligation or is factually impelled to account,” and the account holder can demand an account for the power holder’s actions (Rached, 2016, p. 323). In Dillard and Vinnari (2019)’s framework, accountability comprises *formality*, *substance* and *timing*.

Formality refers to the power relationships between the power holder and the account holder, which could be formal and more or less regulated. That said, the relationships between public and private organisations and their stakeholders in the New Space Economy, for the most part, have not yet been formalised. Instead, these relationships tend to be shaped by the *substance* of the standards and the evaluation criteria to which the power holder is held (Rached, 2016; Dillard and Vinnari, 2019). Philp (2009), for example, distinguishes two poles in accountability-based standards, these being compliance-based and integrity-based systems. Compliance-based systems rely on incentives and sanctions to promote compliance with the rules. By contrast, integrity-based systems are structured around trust in the agent.

The New Space Economy operates on an integrity-based system where accountability relationships move “toward one between a truster and a trustee” (Dillard and Vinnari, 2019, p. 26). *Timing* reflects the “moment the power holder expects a reaction from the account holder, or the moment the latter has the opportunity to respond to the former” (Rached, 2016, p. 331). Therefore, *formality*, *substance*, and *timing* add characteristics to the power relationships above. Timing can be *ex ante* or *ex-post* since accounting can occur before or after the interaction. Further, in either case, reactions can be immediate, gradual, or multi-phased (Rached, 2016). Thus, *formality*, *substance* and *timing* are the elementary units that regulate accountability between power holders and account holders.

Formality – Several studies have highlighted the lack of laws and regulations surrounding space activities and an organisation’s economic, social and environmental responsibilities (De la Roche, 2011; Chrysaki, 2020; Mallovan *et al.*, 2021). As such, there are few formal accountability systems in the sector. Further, the complex nature of hybrid forms of collaboration makes formalising the landscape difficult. On the one hand, accountability does not necessarily need formal rules to operate but can be voluntary, as mentioned above. Space companies could voluntarily commit to conducting space activities more sustainably and responsibly and be more transparent about the impacts and costs of their activities. On the other hand, environmental regulations and policies are considered a prerequisite for reducing

emissions and encouraging sustainable growth (Hashmi and Alam, 2019; Chen *et al.*, 2020; Neves *et al.*, 2020).

Substance – Since integrity-based accountability characterises the New Space Economy, citizens and investors must trust power holders' information. However, according to Bloomfield (2006), public entities can become part of a hybrid organisation without voter approval and avoid debt restrictions by using off-balance-sheet financing. However, avoiding debt constraints does not mean avoiding debt or situations where citizens end up paying. On the contrary, debt constraints can transfer a greater burden of the costs to future generations (Parker and Hartley, 2003). In the UK, public-private partnerships were seen as “yet again screwing the taxpayer” (Bowman, 2001). Therefore, hybrid organisations do not necessarily lead to greater economic efficiency.

For this reason, they deserve monitoring and accountability and close and critical scrutiny (Parker and Hartley, 2003; Hodge and Greve, 2007). Since accounting information can be tailored to either meet or refute the trust-based demands of stakeholders, accounting could play a mediating role in trust-building (La Torre *et al.*, 2020). This way, accounting rules and regulations could create trustful relationships between power holders and account holders while preventing unfairness and abuses of power (Seal and Vincent-Jones, 1997; Willems and Van Dooren, 2011).

Similarly, the relationships within these hybrid private-public entities are also based on trust, even though the parties will inevitably be tied together with a formal contract. Hybrid collaborations are generally steeped in cooperation and mutual trust, but their different interests can create tension (Bloomfield, 2006). The following example shows just such tension between NASA and SpaceX. Even though there was a contract in place, NASA was sceptical that SpaceX would adhere to its timeline:

On September 30, Elon Musk, CEO of SpaceX, told CNN that the Crew Dragon would be ready to carry astronauts into space in three to four months. But NASA Administrator Jim Bridenstine told CNN he wasn't convinced, and due to delays from SpaceX and Boeing (which is at work on a similarly delayed, competitor capsule called Starliner), he anticipated NASA buying more seats aboard Russian capsules. (Letzer, 2019)

Such friction between the two counterparts shows that a formal contract is not always enough to quell disagreement – trust is also required. Additionally, while contractual processes can contribute to forming cooperative relationships, maintaining trustful relationships may require accounting and measurement rules (Seal and Vincent-Jones, 1997).

Timing - Corporate reporting and budget approvals are usually an annual exercise. As Power *et al.* (2003) explain, accounting information in corporate reports can help to rationalise and justify ex-post decisions. Hence, one could say power holders tend to communicate ex-post information. However, considering the huge investments, high risks and economic and social impacts of long-term space activities, account holders require information in a much timelier fashion than in a once-a-year report, as highlighted by Deter (2021):

Will there be a Blue Origin IPO? Unlike Elon Musk, Jeff Bezos hasn't confirmed that investors will see his space company's stock anytime soon. But that doesn't mean the option is off the table. If Blue Origin goes public, investors need to be ready.

With timely information, account holders can react, make their demands heard and influence the power holders' actions.

4. Critiques and reflections on accountability in the New Space Economy

The accountability framework analysed before helps us unveil and understand the main points and elements characterising the accountability systems of actors in the New Space Economy. If private and public actors could embrace hybrid and joint accountability, the power

relationships between them and account holders could be balanced, and their accounting systems could be regulated with accountability at the forefront. These measures would help to ensure a more pluralistic and broader accountability across the New Space Economy. Nevertheless, these actions may not meet their end goals without further understanding society's demand for accountability and the mindset that inspires New Space activities. Thus, this section offers critiques and reflections on the social demand for accountability in the New Space Age and discusses some limitations of regulating its business activities.

The New Space Economy encompasses activities with economic, environmental and social impacts. Space missions are strongly linked to human progress and have also yielded many innovations for protecting the environment and improving the quality of human life. However, current space investments are also driven by recreational motivations. Space tourism is considered the "next big thing" for human progress (Boone *et al.*, 2018). Defined as "the temporary movement of people for non-military reasons beyond the Earth's atmosphere" (Duval and Hall, 2015, p. 450), space tourism is distinct from humanity living in space – but it may be a stepping stone along the way. The claimed mission of bringing human life to other planets is often motivated by saving humanity in the likely future when the Earth will be uninhabitable:

And Elon sees SpaceX as being in the service of humanity, to help create another place for humanity eventually to evolve to if something happens on Earth. (Buss, 2018)

Musk has said his life goal is to create a thriving Mars colony as a fail-safe for humanity in case of a catastrophic event on Earth, such as a nuclear war or Terminator-style artificial intelligence coup. (Holmes, 2018).

Human survival is central to the New Space Age (Reddy, 2018). As the physicist Stephen Hawking argues:

If our species had any hope of survival, future generations would need to forge a new life in space (Deccan Chronicle, 2018).

There are several controversial programmes aimed at guaranteeing the survival of the human species in case of an environmental disaster or the Earth's resource depletion – for example, the Embryo Space Colonization, which involves the transportation of frozen human embryos from Earth to other extrasolar planets (Edwards, 2021; Szocik, 2021). Nevertheless, as mentioned in the *expertise* section of the framework, stakeholders want information on the impact of such initiatives, even if they do not have the technical knowledge to understand them. However, non-financial information is seldom reported (see the discussion under *spatial vectors*). Based on this view, we can imagine a utopian future where, after destroying the Earth, we will be ready to colonise other planets for continued human survival and domination. Terraforming Mars or shielding it from radiation to make it habitable is among the ideas people have had to guarantee human survival when leaving an "undesirable Earth" (Spector and Higham, 2019, p. 5).

This aspiration for human life in space has recently been criticised for its morality. Newman and Williamson (2018, p. 34) state that "there is an ethical obligation to respect or constrain activities on celestial bodies." No global ethical standards apply to scientific research on organic life in space (Damjanov, 2018). Instead, as pointed out in the *consequences* unit of our framework, there is only a voluntary code of conduct and a gaping need for cultural reform in the New Space Age. Organisations involved in New Space activities have prioritised achieving their goals over their operations' ethical, social, and environmental aspects (Newman and Williamson, 2018).

In the debate for and against space exploration, the main arguments of the opponents focus on the amount of money spent to indulge the whims of the wealthy when that money

might be better spent solving more contingent problems that afflict all people. The quotes below summarise the rising protests in public opinion:

We're experiencing climate change, famine, drought, warfare, and we're investing the money needed to solve these problems in space. [...] If the collapse of civilisations is a recurrent theme, then we should be looking for ways of managing the planet's resources in order to make how we live sustainably. The way to do that is not to go charging off into space, wasting unbelievable quantities of money in pursuit of some chimera that we might in one day come back with some valuable mineral. Science should be devoting the sorts of sums of money that it is pumping into space to working out how to manage the climate here on Earth. (Hanbury-Tenison and Bizony, 2017)

To colonise Mars is a sign of an older and recurring social problem. What happens when the rich and powerful isolate themselves from everyday concerns? Musk wants to innovate and leave Earth, rather than to take care of it, or fix it, and stay. At this point in human history, the colonisation of Mars is a distraction from the severe problems facing human societies. The moral detachment of the plan signifies a deeper pathology that afflicts our culture of innovation. (Russell and Vinsel, 2017)

These concerns require moral judgements for humans, as they create a dilemma between what is bad and what is good (Dewey, 1930).

In addition to these moral concerns about our future, the need to make the New Space Economy sustainable for the environment has become evident and compelling (Tapio, 2018; Oltrogge, 2020; Martinez, 2021). According to Spector and Higham (2019, p. 5), "it is noteworthy that the very act of leaving Earth and travelling beyond the biosphere has a significant impact on the Earth's environment." Recent studies have revealed that suborbital launches cause significant changes in global atmospheric circulation, ozone, and temperature distributions (Ross *et al.*, 2010; Toivonen, 2022). Orbital debris from non-operational satellites, fuel gasses emitted when a launcher lifts off the Earth, and the fragments given off from satellite explosions or collisions represent threats to preserving a safe environment in space and the long-term sustainability of New Space activities (Newman and Williamson, 2018; Pardini and Anselmo, 2021). Even the most minor debris (0.01–1 cm) can cause extensive damage. A small piece of metal has the explosive power of a grenade, while those larger than 1 cm can have catastrophic effects (Tan, 2000; Weinzierl, 2018). Already, 6,000 tonnes of debris of different sizes occupy Low Earth Orbit (Weinzierl, 2018). The problem with space junk is just one example of how New Space activities threaten Earth's and space's sustainability (Witze, 2018).

However, space businesses typically disclose very little information to the public about the pollutants they emit during space activities. As argued before, stakeholders are weak in the context of the New Space Economy. Hence, most of the criticisms come from technicians and specialists. We still have very little knowledge of the social and environmental implications of commercial activities in the New Space Age (Di Tullio, 2022). In this way, we are distancing humankind from the natural world and ignoring its limits (Gray and Milne, 2018; Spector and Higham, 2019).

The multifaceted opportunities space businesses create help depict an imaginary future with benefits all about human progress and survival without showing us the potential adverse environmental and social impacts of those dreams. For example, a satellite's accidental re-entry into Earth's atmosphere caused the spacecraft to fall into the Pacific Ocean with about eleven tons of unused, highly toxic fuel on board. However, because of the lack of reporting standards, we do not know whether the fuel tanks exploded high above the Earth nor whether part of the material vaporised and re-condensed into small particles that remained in the atmosphere influencing atmospheric chemistry (Durrieu and Nelson, 2013).

Information to meet stakeholders' needs is not disclosed, and their interests are not protected by regulation. In this integrity-based accountability system, the power holders opt *not* to engage with their investors and the public. According to Quintana (2017, p. 99), there is

a lack of appropriate measures to avoid the “harmful contamination of celestial bodies and adverse changes in the environment of the Earth resulting from the introduction of extra-terrestrial matter.” As discussed in the *formality* section, the current legal and regulatory frameworks do not consider today’s social and environmental aspects of space activities. They do not make private and commercial organisations responsible or liable for specific activities (Quintana, 2017; Mallowan *et al.*, 2021).

Regulation is the primary means of formalising the public’s requests to protect public goods. However, the legal sphere has, so far, been unprepared for the rapid development of space activities. The “Outer Space Treaty,” established in 1967, is considered the foundation of international space law. However, it does not cover new activities like space tourism (Bryce Space and Technology, 2017; Toivonen, 2022). Further, it is state-centric because its rules only address nation-states operating in space (Mallowan *et al.*, 2021), which is unsurprising as governments and federal agencies have dominated space activities for decades (Barbaroux, 2016; Canis, 2016). However, there are open questions and no international consensus about the legal soundness of existing rules for private companies, the legal status of resources in celestial bodies, and what constitutes appropriate conduct for space activities, licensing and data sharing (De la Roche, 2011; Bockel, 2018; Mallowan *et al.*, 2021). Luxembourg, Japan, and the United Arab Emirates have each enacted a domestic legal framework that establishes private rights over the resources mined from space (Weinzierl and Sarang, 2021), creating a grey area of responsibility and jurisdiction, causing the non-appropriation of outer space issue to resurface (Chrysaki, 2020; Mallowan *et al.*, 2021).

Governments and public authorities have recognised the need for broader accountability in space businesses. The public purpose and “common interest of mankind” are the cornerstone of the international space law framework (Mallowan *et al.*, 2021). However, international space law lacks protection for non-humans (Damjanov, 2018). Governments like Finland, space organisations like the Global VSAT Forum, and international intergovernmental organisations like the United Nations are striving to promote guidelines that have a progressive and positive approach to the environment and space sustainability, emphasising the importance of environmental issues in both outer space and Earth (Tapio, 2018; Chrysaki, 2020; Oltrogge, 2020; Martinez, 2021). Nevertheless, consistent with the accountability issues discussed in Section 3, space regulators today have a pressing agenda to regulate space businesses’ activities, address issues of sustainable space operations, the property of space resources, and information sharing between actors conducting space activities (Mallowan *et al.*, 2021).

The following newspaper article headline sums up this twilight zone in regulating space activities:

If a satellite falls on your house, space law protects you — but there are no legal penalties for leaving junk in orbit (Aganaba, 2021)

Thus, while current regulations address people’s safety and protect their property from the risks of space activities, the legislation seems to overlook any liability from space pollution on the environment (Aganaba, 2021). Additionally, the current regulatory frameworks must be revised to consider private sector initiatives and ensure accountability by all the actors involved. Thus, lack of regulation prevents regulating what space companies do and formalising their liability for the risks to human and non-human resources.

5. Conclusion and future research

In this paper, we argue that the New Space Economy results from, and will continue to be inspired by, an anthropocentric view of humanity’s progress toward extending our planetary boundaries. This essay was motivated by the need to understand how we can ensure greater accountability in the New Space Age by meeting the accountability needs arising from new

business models and the social and environmental consequences of the New Space Economy. In this discussion, we examined some of the accountability challenges emerging from the New Space Economy and reflected on the implications that might stem from the lack of accountability space businesses have toward society and the environment.

While acknowledging the need to develop accounting practices for the New Space Economy (Alewine, 2020), we call for accounting and reporting systems to be designed based on accountability, as these are needed to meet the needs of the New Space Age. Following pluralistic accountability (Rached, 2016; Dillard and Vinnari, 2019) and collaborative business models (Lindgren *et al.*, 2010; Rohrbeck *et al.*, 2013), we developed a pluralistic framework for analysing and rethinking the accountability dynamics at play in the New Space Economy. The power relationship between actors is a crucial topic in our analysis and discussion that includes horizontal and vertical relationships between those who hold power, like public entities and space businesses, and those holding the power brokers to account, that is, investors and society. In the form of accountability-based accounting, regulations in the New Space Economy complete this pluralistic accountability system by moderating the power relationships, collaborations and interactions between actors. Considering the limitations of corporate reporting practices outlined above, we argue that regulators should establish procedures and consequences within an accountability system that introduces rules, duties and penalties for the behaviour of space businesses and the public disclosures they need to make.

The barriers to accountability over society and the environment in the New Space Economy come from problems with hybrid organisations. These problems largely stem from the different institutional purposes and logic and the different natures of public and private entities, which make them subject to different political and legitimacy pressures (Bardach and Lesser, 1996; Bryson *et al.*, 2006; Rajala and Kokko, 2021). Thus, the individual accountability systems of public and private entities remain unconnected and unsuitable for establishing overall accountability through collaboration.

We argue that the asymmetry in accountability between private and public entities means hybrid organisations should embrace shared accountability for their social and environmental impacts. This concept of accountability looks at the value created by the hybrid organisation instead of the single entities, meaning that private and public actors participating in a space project should take responsibility for the whole project and its activities instead of limiting it to their legal and organisational boundaries. According to Villani *et al.* (2017), a hybrid organisation's business model is "the bridge through which institutional complexity and value creation mechanism[s] can be linked" (p. 901). The collaborative business model idea helps support the shift from single-entity accountability to pluralistic accountability for a collaborative project. Therefore, rethinking accountability in the New Space Economy would mean building renewed accountability-based systems for space businesses and opening them up to a broader hybrid and pluralistic accountability concept. However, we question whether and how the New Space Economy will embrace overall accountability for the environment and escape from this anthropocentric trap. For this reason, we call for accounting, social and environmental research to contribute to this epistemic purpose.

Despite this paper being based on practical evidence, public information and recent research, we acknowledge the need to provide further empirical evidence to understand the role of accounting in the New Space Economy. Alewine (2020) argues that the academic literature must provide a further understanding of the role accounting can play in the New Space Economy. This essay explores the debate by highlighting accountability issues from a social and environmental perspective. We advocate that social and environmental accounting has significant potential to improve accountability in space activities, helping to create a new way of seeing the relationship between human life, the Earth, and celestial space. It can be an accounting language that causes us to rethink the moral contract between humans and nature and one that grounds our human and corporate accountability in the environment.

5.1 Opportunities for future research in accounting

Space accounting and the New Space Economy are in their infancy. Thus, there is much room for further understanding the relationships between accounting, the New Space Age, and its businesses. Our reflections on corporate accountability in the New Space Economy open research avenues for investigating how the advent of the New Space Age will impact society and its implications for accounting research and practice. Many research questions stem from our reflections that may inspire future accounting research on the New Space Economy.

5.1.1 Hybrid accountability in the New Space Economy. Space accounting research could benefit from empirical research examining the procedures and information disclosed by public and private partners involved in space activities. This research could allow us to understand better the role of social and environmental accounting in the space sector and turn corporate accountability into an accounting language. In this sense, answering the following research questions might provide empirical insights into the dialogue between power holders and account holders in the New Space Economy:

- (1) What social and environmental information is provided by private companies and public agencies in the space sector? Is this information about events on other planets and their consequences for our planet?
- (2) Why do public and private entities in space sectors disclose social and environmental information?
- (3) Since space agencies are active on social media (Bertrand *et al.*, 2015), what communication channels exist to publicly disclose social and environmental information? Do they differ from public to private entities?

Hybrid forms of collaboration are used to realise complex projects and public services. However, several studies have called for accountability solutions due to their complexity. Based on our findings, we believe future research could attempt to answer the following questions:

- (1) How can a collaborative business model solve accountability issues in hybrid organisations?
- (2) How do hybrid organisations engage different stakeholder groups?
- (3) Which procedures do hybrid organisations use to solve social and environmental accountability issues?
- (4) How can hybrid organisations share their responsibilities and information?

5.1.2 The power relationship between the new space actors. Examining the elements that might shift the power balance between account holders and power holders in the New Space Economy would be another fruitful area of future research. Studies might consider experience, training, and the consequences of sanctions that account holders could impose on the power holders. For example:

- (1) How can public stakeholders impose consequences for ethical misconduct by space actors, if any?
- (2) How can information on space activities and their social and environmental impacts be provided in a way that non-technical actors can understand?
- (3) Can social and environmental accounting lead to broader accountability in the New Space Economy?

The Anthropocene era and the concept of planetary boundaries have already gained interest in social and environmental accounting research (Gray and Milne, 2018; Bebbington *et al.*, 2019; Cho *et al.*, 2021). Thus, the following questions may enrich this literature and inspire future research into space accounting:

- (1) Are planetary boundaries considered in space projects and business accountability?
- (2) How does an anthropocentric mindset influence accountability in space businesses?
- (3) How can (or should) space business' social and environmental accountability extend to using extra-terrestrial resources and ecosystems?
- (4) How can nature's voice be heard in the accountability of space businesses?

5.1.3 Regulated accountability-based accounting in the space sector. Future research might also examine the development of national and international regulations to govern space activities and their implications on accounting, transparency rules, and accountability. For example:

- (1) Can rules, procedures and standards ensure further transparency and accountability in the New Space Economy?
- (2) How can regulation improve corporate governance and the accountability of hybrid organisations in the New Space Economy?
- (3) Can regulation improve the asymmetry between public and private entities toward the stewardship of the common goods in the New Space Age?

Note

1. <https://artes.esa.int/european-data-relay-satellite-system-edrs-overview>

References

- Adams, C.A. (2004), "The ethical, social and environmental reporting performance portrayal gap", *Accounting, Auditing & Accountability Journal*, Vol. 17 No. 5, pp. 731-757.
- Aganaba, T. (2021), "If a satellite falls on your house, space law protects you – but there are no legal penalties for leaving junk in orbit", *The Conversation*, available at: <https://theconversation.com/if-a-satellite-falls-on-your-house-space-law-protects-you-but-there-are-no-legal-penalties-for-leaving-junk-in-orbit-160757> (accessed 01 May 2022).
- Alberts, P. (2011), "Responsibility towards life in the early Anthropocene", *Angelaki – Journal of the Theoretical Humanities*, Vol. 16 No. 4, pp. 5-17.
- Alewine, H.C. (2020), "Space accounting", *Accounting, Auditing & Accountability Journal*, Vol. 33 No. 5, pp. 991-1018.
- Almqvist, R., Grossi, G., van Helden, G. and Reichard, C. (2013), "Public sector governance and accountability", *Critical Perspectives on Accounting*, Vol. 24 No. 7, pp. 479-487.
- Antonini, C. and Larrinaga, C. (2017), "Planetary boundaries and sustainability indicators. A survey of corporate reporting boundaries", *Sustainable Development*, Vol. 25, pp. 123-137.
- Argento, D., Grossi, G., Persson, K. and Vingren, T. (2019), "Sustainability disclosures of hybrid organisations: Swedish state-owned enterprises", *Meditari Accountancy Research*, Vol. 27 No. 4, pp. 505-533.
- Ayetej, J.S. (2020), "Support of global accountability for private commercial space actors", *Georgia Journal of International and Comparative Law*, Vol. 48 No. 3, pp. 761-765.
- Bacsardi, L., Birkeland, R., Hornig, A., Shar, M., Morrison, B. and Tsodikovich, Y. (2017), "Present and the future of space internet: the space generation perspective", *New Space*, Vol. 5 No. 4, pp. 257-267.

- Baker, C.R. (2003), "Investigating Enron as a public private partnership", *Accounting, Auditing & Accountability Journal*, Vol. 16 No. 3, pp. 446-466.
- Barbaroux, P. (2016), "The metamorphosis of the world space economy: investigating global trends and national differences among major space nations' market structure", *Journal of Innovation Economics*, Vol. 20 No. 2, pp. 9-35.
- Bardach, E. and Lesser, C. (1996), "Accountability in human services collaboratives - for what? And to whom?", *Journal of Public Administration Research and Theory*, Vol. 6 No. 2, pp. 197-224.
- Baskin, J. (2015), "Paradigm dressed as epoch: the ideology of the Anthropocene", *Environmental Values*, Vol. 24, pp. 9-29.
- Baumgart, A., Vlachopoulou, E., Del Rio Vera, J. and Di Pippo, S. (2021), "Space for the sustainable development goals: mapping the contributions of space-based projects and technologies to the achievement of the 2030 agenda for sustainable development", *Sustainable Earth*, Vol. 4 No. 6, pp. 1-22.
- Bebbington, J. and Larrinaga, C. (2014), "Accounting and sustainable development: an exploration", *Accounting, Organisations and Society*, Vol. 39 No. 6, pp. 395-413.
- Bebbington, J. and Thy, C. (1999), "Compulsory environmental reporting in Denmark: an evaluation", *Social and Environmental Accountability Journal*, Vol. 19 No. 2, pp. 2-4.
- Bebbington, J., Larrinaga, C. and Moneva, J.M. (2008), "Corporate social reporting and reputation risk management", *Accounting, Auditing & Accountability Journal*, Vol. 21 No. 3, pp. 337-361.
- Bebbington, J., Österblom, H., Crona, B., Jouffray, J.B., Larrinaga, C., Russell, S. and Scholtens, B. (2019), "Accounting and accountability in the Anthropocene", *Accounting, Auditing & Accountability Journal*, Vol. 33 No. 1, pp. 152-177.
- Bertrand, P.J., Niles, S.L. and Newman, D.J. (2015), "Human spaceflight in social media: promoting space exploration through twitter", *New Space*, Vol. 3 No. 2, pp. 117-133.
- Bloomfield, P. (2006), "The challenging business of long-term public-private partnerships: reflections on local experience", *Public Administration Review*, Vol. 66 No. 3, pp. 400-411.
- Bockel, J.-M., and Economic and Security Committee (ESC) (2018), "The future of the space industry", *Nato Parliamentary Assembly*, available at: <https://www.nato-pa.int/download-file?filename=/sites/default/files/2018-12/2018%20-%20THE%20FUTURE%20OF%20SPACE%20INDUSTRY%20-%20BOCKEL%20REPORT%20-%2020173%20ESC%2018%20E%20fin.pdf>
- Boiral, O. (2013), "Sustainability reports as simulacra? A counter-account of A and A 1 GRI reports", *Accounting, Auditing & Accountability Journal*, Vol. 26 No. 7, pp. 1036-1071.
- Boone, T.R., Shelley, E.C. and Miller, D.P. (2018), "Launch cost thresholds for economic activity", *New Space*, Vol. 6 No. 3, pp. 201-210.
- Borowitz, M. (2016), "Is it time for commercial weather satellites? Analysing the case of global navigation satellite system radio occultation", *New Space*, Vol. 4 No. 2, pp. 115-122.
- Bovens, M. (2007), "Analysing and assessing accountability: a conceptual framework", *European Law Journal*, Vol. 13 No. 4, pp. 447-468.
- Bowman, L. (2001), "P3-Problem, problem, problem", *Pfist Fight. Project Finance*, September 26-28.
- Broadbent, J. and Guthrie, J. (2008), "Changes in the public sector: a review of recent 'alternative' accounting research", *Accounting, Auditing & Accountability Journal*, Vol. 21 No. 2, pp. 129-169.
- Broadbent, J. and Laughlin, R. (1999), "The private finance initiative: clarification of a future research agenda", *Financial Accountability and Management*, Vol. 15 No. 2, pp. 95-114.
- Brown, J. and Fraser, M. (2006), "Approaches and perspectives in social and environmental accounting: an overview of the conceptual landscape", *Business Strategy and the Environment*, Vol. 15 No. 2, pp. 103-117.

- Bryce Space and Technology (2017), "Global space industry dynamics", Research paper for Australian Government, Department of Industry, Innovation and Science.
- Bryson, J.M., Crosby, B.C. and Stone, M.M. (2006), "The design and implementation of cross-sector collaborations: propositions from the literature", *Public Administration Review*, Vol. 66 SUPPL. 1, pp. 44-55.
- Buss, D. (2018), *For Insights into Elon Musk's Leadership of Tesla, Look at How He Leads SpaceX, Author Says*, Forbes, available at: <https://www.forbes.com/sites/dalebuss/2018/08/31/for-insights-into-elon-musks-leadership-of-tesla-look-at-how-he-leads-spacex-author-says/?sh=1655438563a4> (accessed 20 June 2022).
- Cahan, B.B., Pittman, R.B., Cooper, S. and Cumbers, J. (2018), "Space commodities futures trading exchange: adapting terrestrial market mechanisms to grow a sustainable space economy", *New Space*, Vol. 6 No. 3, pp. 211-226.
- Calzolaio, D., Curreli, F., Duncan, J., Moorhouse, A., Perez, G. and Voegt, S. (2020), "EDRS-C – the second node of the European Data Relay System is in orbit", *Acta Astronautica*, Vol. 177, pp. 537-544.
- Canis, B. (2016), "Commercial space industry launches a new phase", Congressional Research Service. Report prepared for Member and Committees of Congress, available at: <https://sgp.fas.org/crs/space/R44708.pdf>
- Castree, N. (2014), "The anthropocene and the environmental humanities: extending the conversation", *Environmental Humanities*, Vol. 5, pp. 233-260.
- Chen, Y., Fan, X. and Zhoy, Q. (2020), "An inverted-U impact of environmental regulations on carbon emissions in China's iron and steel industry: mechanisms of synergy and innovation effects", *Sustainability*, Vol. 12 No. 3, p. 1038.
- Cho, C.H., Roberts, R.W. and Patten, D.M. (2010), "The language of U.S. corporate environmental disclosure", *Accounting, Organizations and Society*, Vol. 35 No. 4, pp. 431-443.
- Cho, C.H., Senn, J. and Sobkowiak, M. (2021), "Sustainability at stake during COVID-19: exploring the role of accounting in addressing environmental crises", *Critical Perspectives on Accounting*, Vol. 82, 102327.
- Chrysaki, M. (2020), "The sustainable commercialisation of space: the case for a voluntary code of conduct for the space industry", *Space Policy*, Vol. 52, 101375.
- CIA (1998), "Intelligence memorandum. US and Soviet space programs: comparative size", available at: <https://irp.fas.org/cia/product/sovmin66.pdf> (accessed 01 July 2022).
- Conrad, L. (2005), "A structuration analysis of accounting systems and systems of accountability in the privatised gas industry", *Critical Perspectives on Accounting*, Vol. 16 No. 1, pp. 1-26.
- Crawford, I.A. (2016), "The long-term scientific benefits of a space economy", *Space Policy*, Vol. 37 No. 2, pp. 58-61.
- CSIS Aerospace (2020), "State of the space industrial base 2020. A time for action to sustain US economic and military leadership in space", available at: http://aerospace.csis.org/wp-content/uploads/2020/07/State-of-the-Space-Industrial-Base-2020-Report_July-2020_FINAL.pdf
- Dahl, L.B. (2019), *PDS Support for the Democratization of Space*, Jet Propulsion Laboratory, California Institute of Technology, Pasadena.
- Damjanov, K. (2018), "Accounting for non-humans in space exploration", *Space Policy*, Vol. 43, pp. 18-23.
- De la Roche, A.B. (2011), "Space, security and resilience: reflections on the debate", *Space Policy*, Vol. 27 No. 4, pp. 247-249.
- Deccan Chronicle (2018), "Stephen Hawking's final warning: leave Earth in next 200 years or face extinction", available at: <https://www.deccanchronicle.com/lifestyle/viral-and-trending/150318/stephen-hawkings-final-warning-leave-earth-in-next-200-years-or-face.html> (accessed November 2021).

- Deloitte (2019), "New Zealand space economy: its value, scope and structure", available at: <https://www.mbie.govt.nz/assets/new-zealand-space-sector-its-value-scope-and-structure.pdf> (accessed November 2021).
- Denis, G., Alary, D., Pasco, X., Pisot, N., Texier, D. and Toulza, S. (2020), "From new space to big space: how commercial space dream is becoming a reality", *Acta Astronautica*, Vol. 166, pp. 431-443.
- Deter, A. (2021), "Blue Origin stock: when will Bezos' space company IPO?", *Investment*, available at: <https://investmentu.com/blue-origin-stock-ipo/> (accessed 20 June 2022).
- Dewey, J. (1930), "Three independent factors in morals", in Hickman, L.A. and Alexander, T.M. (Eds), *The Essential Dewey: Ethics, Logic, Psychology*, Indiana University Press, pp. 315-320.
- Di Ciaccio, S., Cramarossa, A. and Fatica, M. (2018), "New space: a glance at Italy", *New Space*, Vol. 6 No. 4, pp. 254-261.
- Di Tullio, P. (2022), *The New Space Economy: Business Models, Sustainability Profiles and Accountability*, Franco Angeli, Milano.
- Dillard, J. and Vinnari, E. (2019), "Critical dialogical accountability: from accounting-based accountability to accountability-based accounting", *Critical Perspectives on Accounting*, Vol. 62, pp. 16-38.
- Drake, N. (2016), "Elon Musk: a million humans could live on Mars by the 2060s", *National Geographic*, available at: <https://www.nationalgeographic.com/science/article/elon-musk-spacex-exploring-mars-planets-space-science> (accessed 4 May 2023).
- Dumay, J., Guthrie, J. and Farneti, F. (2010), "GRI sustainability reporting guidelines for public and third sector organisations", *Public Management Review*, Vol. 12 No. 4, pp. 531-548.
- Durrieu, S. and Nelson, R.F. (2013), "Earth observation from space - the issue of environmental sustainability", *Space Policy*, Vol. 29 No. 4, pp. 238-250.
- Duval, D.T. and Hall, M. (2015), "Sustainable space tourism: new destinations, new challenges", in Hall, C.M., Gössling, S. and Scott, D. (Eds), *The Routledge Handbook of Tourism and Sustainability*, Taylor & Francis, pp. 450-460.
- Edwards, M.R. (2021), "Space ectogenesis: securing survival of humans and Earth life with minimal risks – reply to Szocik", *International Journal of Astrobiology*, Vol. 20 No. 4, pp. 323-326.
- English, L. (2005), "Using public-private partnerships to deliver social infrastructure: the Australian experience", in Hodge, G. and Greve, C. (Eds), *The Challenge of Public-Private Partnerships: Learning from International Experience*, pp. 290-304.
- Entrena Utrilla, C.M. and Welch, C. (2017), "Development roadmap and business case for a private Mars settlement", *New Space*, Vol. 5 No. 3, pp. 170-185.
- ESA (2014), "Partnership", available at: https://www.esa.int/Applications/Telecommunications_Integrated_Applications/EDRS/Partnership (accessed 20 February 2021).
- Euroconsult (2022), "Euroconsult estimates that the global space economy totalled \$370 billion in 2021", available at: <https://www.euroconsult-ec.com/press-release/euroconsult-estimates-that-the-global-space-economy-totaled-370-billion-in-2021/#:~:text=Leading%20space%20consulting%20and%20market,totaled%20%24370%20billion%20in%202021> (accessed 22 August 2022).
- Fenwick, M., Kaal, W. and Vermeulen, E. (2017), "Regulation tomorrow: what happens when technology is faster than the law?", *American University Business Law Review*, Vol. 6 No. 3, pp. 561-594.
- Ferry, L. and Eckersley, P. (2015), "Accountability and transparency: a nuanced response to Etzioni", *Public Administration Review*, Vol. 75 No. 1, pp. 11-12.
- Ferry, L., Eckersley, P. and Zakaria, Z. (2015), "Accountability and transparency in English local government: moving from 'matching parts' to 'awkward couple'?", *Financial Accountability and Management*, Vol. 31 No. 3, pp. 345-361.

- Forrer, J., Kee, J.E., Newcomer, K.E. and Boyer, E. (2010), "Public-private partnerships and the public accountability question", *Public Administration Review*, Vol. 70 No. 3, pp. 475-484.
- Foust, J. (2020), "Viasat asks FCC to perform environmental review of Starlink", Space News, December 28, 2020, available at: <https://spacenews.com/viasat-asks-fcc-to-perform-environmental-review-of-starlink/> (accessed 1 February 2021).
- Freeland, S. and Ireland-Piper, D. (2022), "Space Law, Human rights and corporate accountability", *UCLA Journal of International Law and Foreign Affairs*, Vol. 26 No. 1, pp. 1-34.
- Friel, M. (2019), "Tourism as a driver in the space economy: new products for intrepid travellers", *Current Issues in Tourism*, Vol. 23 No. 13, pp. 1581-1586.
- Gohd, C. (2022), "A 'beautiful, beautiful launch': teams celebrate private Ax-1 mission's landmark liftoff", *Space.com*, available at: <https://www.space.com/spacex-axiom-ax1-launch-success-reaction> (accessed 20 June 2022).
- Gray, R., Adams, C. and Owens, D. (2014), *Accountability, Social Responsibility and Sustainability: Accounting for Society and the Environment*, Pearson, Harlow.
- Gray, R. and Milne, M.J. (2018), "Perhaps the Dodo should have accounted for human beings? Accounts of humanity and (its) extinction", *Accounting, Auditing & Accountability Journal*, Vol. 31 No. 3, pp. 826-848.
- Gray, R., Owen, D. and Maunders, K. (1988), "Corporate social reporting: emerging trends in accountability and the social contract", *Accounting, Auditing & Accountability Journal*, Vol. 1 No. 1, pp. 6-20.
- Gren, M. and Huijbens, E. (2014), "Tourism and the Anthropocene", *Scandinavian Journal of Hospitality and Tourism*, Vol. 14 No. 1, pp. 6-22.
- Grossi, G., Vakkuri, J. and Sargiacomo, M. (2021), "Accounting, performance and accountability challenges in hybrid organisations: a value creation perspective", *Accounting, Auditing & Accountability Journal*, Vol. 35 No. 3, pp. 577-597.
- Hanbury-Tenison, R. and Bizony, P. (2017), "Debate: for and against space exploration - is space research a waste of time?", *Engineering and Technology*, available at: <https://eandt.theiet.org/content/articles/2017/10/debate-for-and-against-space-exploration-is-space-research-a-waste-of-time/> (accessed 1 February 2021).
- Hashmi, R. and Alam, K. (2019), "Dynamic relationship among environmental regulation, innovation, CO2 emissions, population, and economic growth in OECD countries: a panel investigation", *Journal of Cleaner Production*, Vol. 231, pp. 1100-1109.
- Hiriart, T. and Saleh, J.H. (2010), "Observations on the evolution of satellite launch volume and cyclicity in the space industry", *Space Policy*, Vol. 26 No. 1, pp. 53-60.
- Hodge, G.A. and Greve, C. (2007), "Public-private partnerships: an international performance review", *Public Administration Review*, Vol. 67 No. 3, pp. 545-558.
- Holmes, O. (2018), "Space: How Far Have We Gone – and where Are We Going?", *The Guardian*, available at: <https://www.theguardian.com/science/2018/nov/19/space-how-far-have-we-gone-and-where-are-we-going> (accessed 1 February 2021).
- Holmgren Caicedo, M., Höglund, L. and Mårtensson, M. (2019), "When calculative practices are no more: on the de-accountingization of the operational level of a public sector agency", *Financial Accountability and Management*, Vol. 35 No. 4, pp. 373-389.
- Kim, D. (2019), "The democratization of space and the increasing effects of commercial satellite imagery on foreign policy", *New Perspectives in Foreign Policy*, Vol. 18, pp. 35-38.
- La Torre, M., Sabelfeld, S., Blomkvist, M., Tarquinio, L. and Dumay, J. (2018), "Harmonising non-financial reporting regulation in Europe: practical forces and projections for future research", *Meditari Accountancy Research*, Vol. 26 No. 4, pp. 598-621.

- La Torre, M., Sabelfeld, S., Blomkvist, M. and Dumay, J. (2020), "Rebuilding trust: sustainability and non-financial reporting and the European Union regulation", *Meditari Accountancy Research*, Vol. 28 No. 5, pp. 701-725.
- Laine, M. (2010), "The nature of nature as a stakeholder", *Journal of Business Ethics*, Vol. 96 Suppl. 1, pp. 73-78.
- Larrinaga, C., Carrasco, F., Correa, C., Llana, F. and Moneva, J. (2002), "Accountability and accounting regulation: the case of the Spanish environmental disclosure standard", *European Accounting Review*, Vol. 11 No. 4, pp. 723-740.
- Letzer, R. (2019), "Why NASA's annoyed about Elon Musk's giant rocket", *Space.com*, available at: <https://www.space.com/starship-crew-dragon-spacex-nasa-bridenstine.html> (accessed 1 March 2021).
- Lindgren, P., Taran, Y. and Boer, H. (2010), "From single firm to network-based business model innovation", *International Journal of Entrepreneurship and Innovation Management*, Vol. 12 No. 2, pp. 122-137.
- Lund, M. and Nielsen, C. (2014), "The evolution of network-based business models illustrated through the case study of an entrepreneurship project", *Journal of Business Models*, Vol. 2 No. 1, pp. 105-121.
- Mallowan, L., Rapp, L. and Topka, M. (2021), "Reinventing treaty compliant 'safety zones' in the context of space sustainability", *Journal of Space Safety Engineering*, Vol. 8 No. 2, pp. 155-166.
- Martin, A. and Beaudry, C. (2015), "Measuring collaboration mechanisms in the Canadian space sector", *New Space*, Vol. 3 No. 3, pp. 172-178.
- Martinez, P. (2019), "The UN COPUOS guidelines for the long-term sustainability of outer space activities", available at: https://swfound.org/media/206891/swf_un_copuos_its_guidelines_fact_sheet_november-2019 (accessed 1 April 2021).
- Martinez, P. (2021), "The UN COPUOS guidelines for the long-term sustainability of outer space activities", *Journal of Space Safety Engineering*, Vol. 8, pp. 98-107.
- Messner, M. (2009), "The limits of accountability", *Accounting, Organisation and Society*, Vol. 34 No. 8, pp. 918-938.
- Moltz, J.C. (2019), "The changing dynamics of twenty-first-century space power", *Journal of Strategic Security*, Vol. 12 No. 1, pp. 15-43.
- Mulgan, R. (2000), "Accountability: an ever-expanding concept?", *Public Administration*, Vol. 78 No. 3, pp. 555-573.
- Nakahodo, S. and Gonzalez, S. (2020), "Creating startups with NASA technology", *New Space*, Vol. 8 No. 3, pp. 137-145.
- Neves, S., Marques, A. and Patricio, M. (2020), "Determinants of CO2 emissions in European Union countries: does environmental regulation reduce environmental pollution?", *Economic Analysis and Policy*, Vol. 68, pp. 114-125.
- Newman, C.J. and Williamson, M. (2018), "Space sustainability: reframing the debate", *Space Policy*, Vol. 46, pp. 30-37.
- OECD (2004), "Space 2030. Exploring the future of space applications", *OECD*, doi: [10.1787/9789264020344-en](https://doi.org/10.1787/9789264020344-en).
- OECD (2011), "Introduction", *The Space Economy at a Glance 2011*, OECD Publishing, Paris.
- Oltrogge, D.L. (2020), "Ideal mix of treaties, guidelines, regulations and industry best practices for space sustainability", *8th Satellites End of Life and Sustainable Technologies Workshop*, Paris, January 22-23, CNES, Paris.
- Owen, D., Gray, R. and Bebbington, J. (1997), "Green accounting: cosmetic irrelevance or radical agenda for change?", *The Asia Pacific Journal of Anthropology*, Vol. 4 No. 2, pp. 175-198.

- O'Dwyer, B., Unerman, J. and Hession, E. (2005), "User needs in sustainability reporting: perspectives of stakeholders in Ireland", *European Accounting Review*, Vol. 14 No. 4, pp. 759-787.
- O'Neill, O. (2006), "Transparency and the ethics of communication", in Hood, C. and Heald, D. (Eds), *Transparency; the Key to Better Governance?*, Oxford University Press, Oxford, pp. 75-90.
- Pardini, C. and Anselmo, L. (2021), "Evaluating the impact of space activities in low earth orbit", *Acta Astronautica*, Vol. 184, pp. 11-22.
- Parker, L. and Gould, G. (1999), "Changing public sector accountability: critiquing new directions", *Accounting Forum*, Vol. 23 No. 2, pp. 109-135.
- Parker, D. and Hartley, K. (2003), "Transaction costs, relational contracting and public private partnerships: a case study of UK defence", *Journal of Purchasing and Supply Management*, Vol. 9, pp. 97-108.
- Philp, M. (2009), "Delimiting democratic accountability", *Political Studies*, Vol. 57 No. 1, pp. 28-53.
- Poon, M. and Olen, H. (2015), "Does literacy improve finance?", *Public Understanding of Science*, Vol. 24 No. 3, pp. 272-284.
- Power, M. and Laughlin, R. (1992), "Critical theory and accounting", in Alvesson, M. and Willmott, H. (Eds), *Critical Management Studies*, SAGE Publications, London.
- Power, M. and Laughlin, R. (1996), "Habermas, law and accounting", *Accounting, Organisations and Society*, Vol. 21 No. 5, pp. 441-465.
- Power, M., Laughlin, R. and Cooper, D.J. (2003), "Accounting and critical theory", in Alvesson, M. and Willmott, H. (Eds), *Studying Management Critically*, pp. 132-156.
- Puroila, J. and Mäkelä, H. (2019), "Matter of opinion: exploring the socio-political nature of materiality disclosures in sustainability reporting", *Accounting, Auditing & Accountability Journal*, Vol. 32 No. 4, pp. 1043-1072.
- Quintana, E. (2017), "The new space Age", *The RUSI Journal*, Vol. 162 No. 3, pp. 88-109.
- Rached, D.H. (2016), "The concept(s) of accountability: form in search of substance", *Leiden Journal of International Law*, Vol. 29 No. 2, pp. 317-342.
- Rajala, T. and Kokko, P. (2021), "Biased by design – the case of horizontal accountability in a hybrid organisation", *Accounting, Auditing & Accountability Journal*, Vol. 35 No. 3, pp. 830-862.
- Ray, S. (2021), "Is SpaceX really worth \$74 billion?", *Forbes*, available at: <https://www.forbes.com/sites/greatspeculations/2021/04/16/is-spacex-really-worth-74-billion/?sh=6af582925127> (accessed 1 May 2022).
- Reddy, V.S. (2018), "The SpaceX effect", *New Space*, Vol. 6 No. 2, pp. 125-134.
- Roberts, J. (1991), "The possibilities of accountability", *Accounting, Organisations and Society*, Vol. 16 No. 4, pp. 355-368.
- Roberts, J. (2009), "No one is perfect: the limits of transparency and an ethic for 'intelligent' accountability", *Accounting, Organisations and Society*, Vol. 34, pp. 957-970.
- Roberts, J. and Scapens, R. (1985), "Accounting systems and systems of accountability – understanding accounting practices in their organisational contexts", *Accounting, Organisations and Society*, Vol. 10 No. 4, pp. 443-456.
- Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S.I., Lambin, E., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H., Nykvist, B., De Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sorlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. and Foley, J. (2009), "Planetary boundaries: exploring the safe operating space for humanity", *Ecology and Society*, Vol. 14 No. 2, pp. 32-65.
- Rohrbeck, R., Konnertz, L. and Knab, S. (2013), "Collaborative business modelling for systemic and sustainability innovations", *International Journal of Technology Management*, Vol. 63 Nos 1/2, pp. 4-23.

- Ross, M., Mills, M. and Toohey, D. (2010), "Potential climate impact of black carbon emitted by rockets", *Geophysical Research Letters*, Vol. 37 No. 24, pp. 1-6.
- Russell, A. and Vinsel, L. (2017), "Whitey on Mars", *Aeon*, available at: <https://aeon.co/essays/is-a-mission-to-mars-morally-defensible-given-todays-real-needs> (accessed 1 May 2021).
- Sadat, M. and Siegel, J. (2022), *Space Traffic Management: Time for Action*, Atlantic Council, available at: https://www.atlanticcouncil.org/wp-content/uploads/2022/08/Space-traffic-management_time-for-action.pdf (accessed 3 August 2022).
- Seal, W. and Vincent-Jones, P. (1997), "Accounting and trust in the enabling of long-term relations", *Accounting, Auditing & Accountability Journal*, Vol. 10 No. 3, pp. 406-431.
- Shaoul, J., Stafford, A. and Stapleton, P. (2012), "Accountability and corporate governance of public-private partnerships", *Critical Perspectives on Accounting*, Vol. 23 No. 3, pp. 213-229.
- Sinclair, A. (1995), "The chameleon of accountability: forms and discourses", *Accounting, Organizations and Society*, Vol. 20 No. 3, pp. 219-237.
- Spector, S. and Higham, J.E.S. (2019), "Space tourism in the Anthropocene", *Annals of Tourism Research*, Vol. 79, 102772.
- Starik, M. (1995), "Should trees have managerial standing? Toward stakeholder status for non-human nature", *Journal of Business Ethics*, Vol. 14 No. 3, pp. 207-217.
- Steffen, W., Crutzen, P.J. and McNeill, J.R. (2007), "The Anthropocene: are humans now overwhelming the great forces of nature?", *Ambio*, Vol. 36 No. 8, pp. 614-621.
- Steffen, W., Grinevald, J., Crutzen, P. and McNeill, J. (2011), "The Anthropocene: conceptual and historical perspectives", *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, Vol. 369 No. 1938, pp. 842-867.
- Strada, G.M. (2018), "Growing the space economy: the downstream segment as a driver", *Space Industry Association of Australia*, available at: https://sasic.sa.gov.au/wp-content/uploads/2020/10/gianluca-m-strada-2018_growing-the-space-economy_the-downstream-segment-as-a-driver_sasic.pdf
- Sweeting, M. (2018), "Modern small satellites – changing the economics of Space", *Proceedings of the IEEE*, Vol. 106 No. 3, pp. 343-361.
- Szocik, K. (2021), "Humanity should colonise space in order to survive but not with embryo space colonisation", *International Journal of Astrobiology*, Vol. 20 No. 4, pp. 319-322.
- Tan, D. (2000), "Towards a new regime for the protection of the outer space as the province of all mankind", *Yale Journal of International Law*, Vol. 25, pp. 145-194.
- Tapio, J. (2018), "The Finnish space act: en route to promoting sustainable private activities in outer space", *Air and Space Law*, Vol. 43 Nos 4/5, pp. 387-409.
- Toivonen, A. (2022), "Sustainability dimensions in space tourism: the case of Finland", *Journal of Sustainable Tourism*, Vol. 30 No. 9, pp. 2223-2239.
- Tucker, B.P. and Alewine, H.C. (2021), "Space for accounting and accountability: realising potential management accounting research contributions to the space sector", *Accounting, Auditing & Accountability Journal*, Vol. 35 No. 6, pp. 1353-1374, doi: [10.1108/AAAJ-08-2021-5411](https://doi.org/10.1108/AAAJ-08-2021-5411).
- Tucker, B.P. and Alewine, H.C. (2022), "Accounting for the new space Age", *Accounting, Auditing & Accountability Journal*.
- Unerman, J., Bebbington, J. and O'Dwyer, B. (2018), "Corporate reporting and accounting for externalities", *Accounting and Business Research*, Vol. 48 No. 5, pp. 497-522.
- United Nations (2018), *European Global Navigation Satellite System and Copernicus*, Supporting the Sustainable Development Goals, Vienna.
- Veclani, A., Darnis, J. and Miranda, C. (2011), *The Galileo Programme: Management and Financial Lessons Learned for Future Space Systems Paid Out of the EU Budget*, European Parliament, available at: [https://www.europarl.europa.eu/RegData/etudes/etudes/join/2011/433833/EXPOSE_DE_ET\(2011\)433833_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/etudes/join/2011/433833/EXPOSE_DE_ET(2011)433833_EN.pdf)

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- Villani, E., Greco, L. and Phillips, N. (2017), "Understanding value creation in public-private partnerships: a comparative case study", *Journal of Management Studies*, Vol. 54 No. 6, pp. 876-905.
- Vittori, D., Natalicchio, A., Panniello, U., Messeni Petruzzelli, A. and Cupertino, F. (2022), "Business Model Innovation between the embryonic and growth stages of industry lifecycle", *Technovation*, Vol. 117, 102592.
- Weinzierl, M. (2018), "Space, the final economic frontier", *The Journal of Economic Perspectives*, Vol. 32 No. 2, pp. 173-192.
- Weinzierl, M. and Sarang, M. (2021), "The commercial space Age is here", *Harvard Business Review*, available at: <https://hbr.org/2021/02/the-commercial-space-age-is-here>
- Willems, T. and Van Dooren, W. (2011), "Lost in diffusion? How collaborative arrangements lead to an accountability paradox", *International Review of Administrative Sciences*, Vol. 77 No. 3, pp. 505-530.
- Williamson, R.A. (2012), "Assuring the sustainability of space activities", *Space Policy*, Vol. 28 No. 3, pp. 154-160.
- Wilson, J.R. (2008), *Space Program Benefits: NASA's Positive Impact on Society*, National Aeronautics and Space Administration, available at: https://www.nasa.gov/50th/50th_magazine/benefits.html (accessed 9 November 2020).
- Witze, A. (2018), "The quest to conquer Earth's space junk problem", *Nature*, Vol. 561 No. 7721, pp. 24-26.
- Wooten, J.O. and Tang, C.S. (2018), "Operations in space: exploring a new industry", *Decision Sciences*, Vol. 49 No. 6, pp. 999-1023.

Corresponding author

Patrizia Di Tullio can be contacted at: patrizia.ditullio@unich.it