The Space Economy: Review of the Current Status and Future Prospects

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1 Introduction

Space, once the final frontier and a symbol of human aspiration, has transitioned from a realm of exploration to an indispensable backbone of our global infrastructure. Since Neil Armstrong's historic lunar step in 1969, our reliance on space has expanded exponentially, permeating every facet of modern life. From satellite-assisted navigation to global communication networks, space systems have become integral to both civilian and military operations. Beyond its immediate applications, the burgeoning space economy stands testament to the increasing commercial and strategic value of space. As we stand on the cusp of a new era, the development and growth of the space economy not only promise unprecedented opportunities but also underscore the need for sustainable

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and responsible utilization of the space domain. Space harbors immense untapped potential to address future crises, stimulate job creation, and foster innovation within the space industry (European Commission, 2016), and it is widely anticipated that, in the forthcoming years, space entrepreneurs offering economical and accessible space strategies will be instrumental in shaping the progression of the space economy (Peeters, 2021). Access to space is invariably viewed as a critical component of sovereignty and autonomy. The metamorphosis of the space sector into the contemporary space economy symbolizes a nascent industry, stemming from regulatory shifts, the influx of novel contenders, and the inception of space agencies partnering with businesses to foster space advancement (Denis et al., 2020; Weinzierl, 2018).

Academic analysis of the economic aspects of space activities has gradually matured into a specialized field, yet the task of comprehensively classifying and as such, understanding the space economy continues to present significant challenges (OECD, 2020, 2022; Weinzierl, 2018). In advanced economies, the complexity of the space economy is becoming ever more evident, and the distinction between activities related to space and those that aren't is progressively diminishing (Profitiliotis & Loizidou, 2019b).

While space economy research has rightfully begun to garner broader academic attention, it still remains fraught with ambiguities and misunderstandings. One of the most significant gaps is the absence of a comprehensive theoretical framework specifically tailored for understanding and classifying the activities of the space economy in terms of international business and their linkage to the broader economy. Existing theories in economics and business, while providing initial scaffolding, seem to not fully encapsulate the unique complexities and multidisciplinary nature of

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space activities. This absence not only hinders nuanced, targeted research but also limits our understanding of various business intricacies within the domain. Moreover, despite the growth in data availability and the maturation of the field, there is a conspicuous absence of standardized metrics and frameworks for assessing the space economy globally. This lack of standardization not only hampers cross-national comparisons but also poses challenges for policymakers and stakeholders in making informed decisions.

Furthermore, previous literature has not adequately addressed several pivotal questions. The establishment of international standards to ensure the comparability of space economy statistics across different countries remains an unresolved issue (OECD, 2022). The role of new entrants, such as business enterprises in space activities, is evolving, but the future industry dynamics are not yet fully understood (Denis et al., 2020; Profitiliotis & Loizidou, 2019b). Policymakers must contemplate how enhanced statistics on the space economy can guide policy decisions and investments in the space sector (Emen, 2020).

There seems to be an urgent need for a unified framework to comprehensively categorize the economic activities within the space economy, considering its multifaceted nature and diverse impacts on the broader economy. Such a framework should ideally integrate international business theories specific to the space economy, providing a structured perspective for examining this emerging field. As this area of study is novel and evolving, our study aims to act as a proof of concept, identifying foundational principles for developing such a framework. We propose using a modified version of the OECD approach as a basis for this framework. This approach, detailed in the OECD Handbook on Measuring the Space Economy, encompasses a broad spectrum of economic activities within the space domain (OECD, 2020).

Using the said approach, our aim for this chapter was to identify key enablers and areas of challenge within the space economy, so that we could gain a better understanding of the macro-level potential and challenges of the domain, while simultaneously testing the feasibility of the proposed framework for such research. In order to achieve a broad coverage of the economic activities within the space economy, we have conducted a systematic literature review meticulously selecting and examining a range of academic sources specifically focused on the space economy. Our approach proved fruitful as we were able to identify a significant number of macro-level trends that have played important

roles in the emergence of the space economy and those that may guide its development in the coming years. Ultimately, by providing such a common frame of reference, our goal is to ensure that the benefits of space exploration and commercialization are maximized and responsibly managed for the sustainable growth of the global economy.

2 Methodology

2.1 Selection of Relevant Articles

A systematic literature review was employed as our primary research method. This approach is renowned for its effectiveness in delivering a comprehensive and current understanding of specific themes. It enables an in-depth exploration of the research topic, allowing for a nuanced comparison and contrast of findings from previous studies (Paul & Rialp Criado, 2020). In identifying relevant literature, we adhered to a rigorous process that included systematic search strategies and evaluative criteria, as advocated by Littell et al. (2008) and Palmatier et al. (2018) (Littell et al., 2008; Palmatier et al., 2018; Paul & Rialp Criado, 2020). This method ensured a thorough and unbiased collection of pertinent studies, setting a solid foundation for our research. First, we applied search words to find relevant literature published between 2018 and 2022. The keywords (space economy, satellite account, new space economy, space economic, and space economics) were selected based on the aim of this study, and they should appear within titles, abstracts, or the entire content. The timeframe for the chosen articles is based on the 2nd edition of the OECD Handbook on measuring the space economy, which highlights that the most important space economy literature has been published after 2017. To find relevant literature, we utilized six main databases covering a wide range of publications across different disciplines in business, economics, information systems, engineering, and so on to ensure that we obtained all relevant articles on the topic. The databases employed were SAGE, SCOPUS, IEEE, ABI, EBSCO, and Taylor and Francis. The search was conducted between September 13, 2022, and September 19, 2022, and again between January 6, 2023, and January 8, 2023. To maintain academic quality of the study, we focused on peer-reviewed academic publications and excluded marketing and industry reports. Table 1 demonstrates the inclusion/exclusion criteria for articles found

Table 1 Selection process and criteria for accepted articles

Phase 1	*Phase 2*	*Phase 3*	*Phase 4*	*Phase 5*	*Phase 6*
Database query (13.9.—19.9.2022): SAGE, SCOPUS, IEEE, ABI, EBSCO (Academic Search Elite, Business Source Premier, eBook Collection and Regional Business News) and Taylor and Francis	Titles and abstracts were verified, and selection was made based on them	Only publications written in English were accepted	Articles were read and those that did not deal with the space economy were eliminated	New database query 6.1.-8.1.2023 (articles after the first query to 31.12.2022), phases 2 to 4	Articles were categorized based on the findings in an Excel table
3258 articles	121 articles	117 articles	57 articles	225 articles, from which 15 fulfilling the set criteria	72 articles

in the databases. Altogether, we found 72 articles that fulfilled selection criteria and were accepted for the ultimate analysis.

2.2 Selection of Relevant Articles

The articles found were published in a wide range of journals, varying from publications focused on space-related issues to more general outlets in the economics and management fields. The most relevant articles were found to be published in the core, leading research journals in space politics and policy, technical knowledge and information, international business, international economics, and international management literature.

There was also a great variation in the journals as the recognized articles were published in 45 different journals, of which seven journals have published more than one article examined in this chapter. The most publications were in Acta Astronautica (14), Space Policy (12), Astropolitics (9), and IEEE Access (3), representing 49% of the total number of selected articles. It is also important to note that space economy research has focused more on publications concentrating on space sciences than on those dealing directly with economic/financial/

commercial research. Based on the years of publication (2018, 11; 2019, 9; 2020, 15; 2021, 11 and 2022, 26), it can be argued that for 2022 a significant increase can be observed compared to earlier years. A total of 214 authors contributed to writing the selected articles, of which 8 authors (Almorad, Al-Naffour, Bowen, Dahrouj, Alouini, Li, Loizidou, Profitiliotis, and Saeed) contributed to two different articles. Based on this, it can be claimed that no single author can be identified as a definite leader in space economy research.

When examining the articles from both geographical and organizational perspectives, it is evident that the majority of the research is focused on the United States, followed by China and Europe (EU). In contrast, Russia's role is highlighted more for its historical achievements in space conquest than for its recent innovations in the development of the new space economy. When doing a similar comparison for organizations (companies) studied, the dominant role of SpaceX and other US companies in shaping the development and management of the new space economy is prominent.

In our research, we have adopted the classification of space activities into segments as outlined in the OECD Handbook on Measuring the Space Economy (OECD, 2020). This classification includes eight well-established segments; Satellite Communications, Positioning, Navigation and Timing (PNT), Earth Observation (EO), Space Transportation, Space Exploration, Science, Space Technologies, and Generic Technologies or Components that enable space capabilities. Like some organizations, we categorize "defense" as a distinct application within our framework to clearly differentiate between civilian and military activities in the space sector. Furthermore, our systematic literature review has identified three additional categories that are useful in the classification of economic activities within the space economy. These are:

1. **Co-operation:** This category emphasizes the importance of collaborative efforts and partnerships in the space sector. It includes international, intergovernmental, and commercial collaborations which are pivotal in advancing space exploration and technology.
2. **Legal:** The legal aspect covers the regulatory frameworks and legal considerations necessary for space activities. This includes space law, policies governing space exploration, and the use of outer space.
3. **Satellite Orbit/Constellation/Size:** This category delves into the technical specifics of satellite deployment, including considerations

of orbit types, satellite constellations for various applications, and the size and capabilities of different satellites.

By incorporating these additional categories derived from our literature review into the OECD's framework, our chapter offers a more comprehensive and nuanced understanding of the space economy, reflecting its evolving and multifaceted nature.

3 Findings

3.1 Emergence of a Sustainable Commercial Space Economy

The evolution of the space economy can be traced through three distinct phases: government-driven, industry-driven, and entrepreneur-driven. The first phase was characterized by government institutions such as NASA playing a central role in the sector, procuring from aerospace firms and undertaking major space missions driven by national prestige (Bowen, 2018b; Emen, 2020; Peeters, 2021; Tucker & Alewine, 2022). The launch of Russia's Sputnik I in 1957, which stimulated both the space race and the rapid development of international space law, was further shaped by the competitive dynamics of the Cold War, particularly the "Space Race" between the United States and the Soviet Union (Bashlakov-Nikolaev et al., 2022; Emen, 2020). That is, the ability to launch satellites and send humans to space was seen as a demonstration of technological prowess and economic strength, contributing to a nation's international standing and influence. This prestige factor continues to play a role in the space programs of both established and emerging spacefaring nations (Cvetkovic et al., 2022; Rementeria, 2022).

In the second phase, commercial space applications became prominent, transforming the dynamics of the space industry. Previously dominated by public actors and their prime business contractors, the industry began to attract new commercial entities. Decades of consistent public funding and government backing propelled this transition, allowing space technology to drive expansion in other segments with a more commercial orientation (Profitiliotis & Loizidou, 2019b). The growth of the space economy is mostly enabled by advancements in various space technologies, governmental support, and the strategic importance of these technologies for defense and military purposes. Governmental support has been a critical enabler for the growth of the space economy (Denis et al., 2020;

Lambakis, 2018; López et al., 2018). The ability to monitor and collect data about the Earth's surface and atmosphere from space provides a strategic advantage in terms of situational awareness and intelligence gathering. While space activities were largely state driven, they began to involve private companies as collaborators in space research activities (Emen, 2020).

A surge of entrepreneurial involvement, powered by equity funding, characterizes the third phase, new space. The emergence of disruptive innovations has created new markets and value networks, often initiated by outsiders and entrepreneurs. The space economy has experienced this disruption, leading to significant shifts in established market dynamics (Denis et al., 2020).

3.2 Enablers of a Sustainable Commercial Space Economy

Based on our literature review, we identified seven segments that seem to have acted as enablers for the emergence of a sustainable space economy. Those were defense, PNT, space exploration, space transportation, satellite communications, EO, and science. Among these, the need for defense, PNT, space exploration, and space transportation solutions stand out as the primary drivers for space-related economic activities in the emerging days of the space economy. These four main drivers are elaborated in detail next.

Firstly, defense emerged as a paramount consideration due to historical and sustained investments in space for defense purposes, as elaborated in 31 articles. These investments have led to technological breakthroughs and infrastructure developments fundamental to the growth of the space economy. The genesis and evolution of the space economy were significantly influenced by nations' defense and military imperatives. Discoveries about the vulnerability of space assets prompted a strategic shift toward the importance of space for national security and corresponding investments in space technologies (Bowen, 2018b; Lambakis, 2018). The military focus in space extended beyond merely protecting national interests, evolving into an instrument of geopolitical dominance and reshaping international relations. In this light, the launch of satellites and advanced space weaponry became symbols of global influence, not just military assets (Rementeria, 2022). The private sector's involvement in defense has spurred innovation through public–private partnerships, igniting debates

over the commercialization of national security. While these collaborations introduced dual-use solutions and cost efficiencies, they also underscored the need to balance innovation with control over essential military capabilities (Chavy-Macdonald et al., 2021; Lickfold & Jetter, 2019). International rivalries in space, exemplified by milestones like the moon race, intensified this drive, with nations investing heavily in space technology to assert supremacy (Rementeria, 2022; Szocik, 2019). Notably, while many space technologies are developed exclusively for civilian (peaceful) use, innovations such as PNT or satellite communications remain crucial for various defense and security agencies, and their development cannot always be easily categorized easily into strictly military or non-military solutions.

Secondly, PNT services played a central role in driving the growth of the space economy. This was indicated in 26 articles. The significance of these services, which play a key role in a wide variety of applications on Earth, from navigation and logistics to telecommunications and disaster management, is underlined. The demand for dependable PNT services has spurred investment and innovation in the space sector, thereby increasing its growth. The rapid expansion of the space economy is intricately tied to the advancement of PNT technologies, as clearly demonstrated by Global Navigation Satellite Systems (GNSS) such as the US GPS, Chinese Beidou, European Galileo, and Russian GLONASS. These technologies have catalyzed diverse applications, from precision weaponry to financial transactions and agricultural innovations (Bowen, 2018a; Lickfold & Jetter, 2019). The role of governments in the PNT sector has been pivotal as PNT has strategic importance in several domains such as national security, environmental management, and agriculture (Aloini et al., 2022; Bowen, 2018a, 2018b; Chavy-Macdonald et al., 2021; Lambakis, 2018; Oyewole, 2020). Further, PNT infrastructure greatly elevates a nation's international prestige and technological stature (Rementeria, 2022; Weinzierl, 2018).

Thirdly, based on 45 (24 + 21) articles, space exploration and space transportation have also had a crucial influence on the formation of a space economy (Alewine, 2020; Bi et al., 2022; Elvis & Milligan, 2019; Jakhu et al., 2020). These technologies, ranging from launching satellites into orbit to enabling human space travel, have revolutionized various sectors, including defense, finance, agriculture and maritime traffic management, becoming an integral part of our global, wireless, and mobile information infrastructure (Bi et al., 2022; Lambakis, 2018;

Weinzierl, 2018). Simultaneously, these advancements in space transportation systems have played a vital role in broadening access to space, thereby fostering the expansion of the space economy through cheaper and easier delivery methods for hardware, that is essential for providing other space economy-related services (Bi et al., 2022; Chavy-Macdonald et al., 2021; Kumar et al., 2020).

3.3 Present Status of the Space Economy and Its Most Essential Elements

Based on the reviewed literature, the present status of the space economy reflects significant growth, diversification, and commercialization of the industry. The commercial space sector is projected to reach a market value of $2.7 trillion by 2045 and encompasses a wide range of activities ranging from space manufacturing and asteroid mining to colonization efforts to other celestial bodies (Toivonen, 2022; Weinzierl, 2018). Governmental interventions have been pivotal in molding the space economy, as they orchestrate regulations that guide business practices and stimulate expansion across diverse domains, encompassing areas such as direct consumer applications and personal entertainment (Argentiero & Falcone, 2020; Toivonen, 2022). The heavy government interest toward the sector is also unlikely to disappear, due to its high weight in many critical fields. As Jakhu et al. (2020) put it, the space sector acts as a kind of linchpin for numerous industries, with an array of over 2200 satellites originating from more than 80 countries delivering several services across the globe. It could be said that organizations delivering services within the space economy context are primarily enablers for other segments. Next, we present eight key elements of space economy. Satellite orbit and constellation size has not been discussed as a unique theme, as it is covered within other satellite-related factors. Table 2 presents each of the segments in terms of how the analyzed literature sees the segment in terms of developments in the space economy. It is notable that many of the segments are seen both as slowing down the space economy development, while at the same time offering significant potential. This is logical, because if the challenges within the said segments can be overcome, it would offer huge future potential.

Satellite communications have become a cornerstone in the evolving space economy, with their applications permeating various sectors, from telecommunications and broadcasting to remote sensing and the Internet

Table 2 Amount of literature mentioning a specific space economy segment, grouped by narrative presented in the mentioning literature

Segment of the space economy	*Slowing down the development of the space economy*	*Created the basis for space economy growth*	*Requirement for the space economy to develop*	*Future potential for the space economy*
Co-operation			37	8
Defense		31		20
Earth Observation (EO)		16	3	38
Generic technologies or components that may enable space capabilities	18		42	51
Legal	18			
Positioning, navigation and timing (PNT)		26	3	26
Satellite communications		18	3	43
Satellite orbit/constellation/size			22	55
Science	5	9	4	36
Space exploration		24		45
Space technologies	43		31	53
Space transportation	4	21	25	44
Grand total	**88**	**145**	**170**	**419**

of Things (IoT). As the global space economy approaches a valuation of over $350 billion, satellite services, particularly communications, are poised to account for a significant portion of this growth (Lauer, 2022). The ubiquity of these services, essential for internet connectivity, has expanded their reach to all nations (Lambakis, 2018). The integration of 5G and 6G technologies with satellite systems is heralding a new era in satellite-enabled services, promising reduced communication latencies and enhanced global internet service (Ho-Baillie et al., 2022; Hoyhtya et al., 2022; Jha et al., 2022; Saeed et al., 2021). Mega constellations, exemplified by initiatives like Starlink, are reshaping the satellite communications paradigm, offering ease of deployment and use.

PNT services, including GNSS, are foundational to, e.g., aviation, marine transportation, financial services, and military operations. They ensure precise navigation, timing, and efficient data transmission, highlighting their economic and strategic significance (Bowen, 2018a; Van Camp & Peeters, 2022). The rising demand for PNT services underscores their diverse applications, from aiding accurate navigation in aviation to ensuring transaction timestamp in finance or providing location-based mobile applications. Their military potential is also paramount, bolstered by satellite constellations and private investments, offering strategic advantages in operations and communication (Rementeria, 2022). The blend of governmental and commercial interests in PNT has spurred investments and advancements, but addressing challenges, such as orbital congestion and electromagnetic spectrum saturation, is essential for sustainable growth (Bowen, 2018a; Chavy-Macdonald et al., 2021).

Earth Observation (EO) technologies have become central to the space economy, expanding their capabilities from tracking military maneuvers to monitoring environmental changes. The commercial sector's access to advanced imagery underscores EO's indispensable role in modern society (Bowen, 2018a; Chavy-Macdonald et al., 2021). The pressing environmental challenges of today necessitate innovative satellites and sensors. Reduced costs, rapid technological advancements, and the rise of small satellite manufacturing are beginning to meet this demand. Emerging trends in EO, particularly in low earth orbit (LEO) constellations, are beginning to provide continuous video from space. This, coupled with the development of image analytics services, is opening new markets, and solidifying the importance of EO across traditional sectors such as climate monitoring and defense, but also pushing the services to new sectors such as finance. As technology advances, the role of EO-services continues to grow, promising innovative opportunities in both public and private sector (Denis et al., 2020; Rementeria, 2022).

Space transportation has, especially in the past few years emerged as a pivotal component in the burgeoning space economy, with its trajectory shaped by factors such as cost, delivery time, and technological risk acceptance (Denis et al., 2020; Rementeria, 2022). The influx of new entrants aiming to democratize access to space and reduce launch costs underscores the segment's significance (Friel, 2020). This trend is exemplified by companies such as SpaceX, which have revolutionized the industry with innovations such as reusable rockets and competitive launch

systems (Denis et al., 2020). Historically, space transportation was dominated by national entities, with orbital launchers primarily serving military objectives (Denis et al., 2020). However, the contemporary landscape is witnessing a shift characterized by the democratization of space and a burgeoning commercial sector. This is also opening significant opportunities for other parts of the space economy, as the cost of delivering essential payloads to orbit and beyond is dropping rapidly.

Space exploration began in 1957 and has since been a catalyst for technological revolutions culminating in human spaceflight. Historically dominated by state actors, the domain is now witnessing a transformative shift with the entry of commercial and private stakeholders, adding new dimensions to the exploration narrative (Kumar et al., 2020; Marzuki & Newell, 2021). The impetus provided by space exploration has spurred the inception of novel technologies and industries. Establishments such as lunar bases are potential testbeds for cutting-edge technologies that encompass energy generation, water processing, and space robotics. These innovations symbolize the profound knowledge generation intrinsic to the contemporary space sector (Argentiero & Falcone, 2020; Bi et al., 2022). Furthermore, the exploration of celestial bodies, such as Mars, has become a tangible reality, yielding a vast magnitude of data. The diminishing resources on Earth have pivoted attention toward the potential of extraterrestrial resource extraction, marking a transformative phase in space utilization (Bi et al., 2022; Jakhu et al., 2020).

Science encompassing human spaceflight is a pivotal component of the space economy. Such pursuits not only establish a distinct market but also catalyze the inception of innovative technologies, which subsequently find commercial applications. The escalating environmental challenges and the imperatives of climate change have accelerated the development of advanced satellites and sensors, delivering indispensable meteorological and climatic insights (Denis et al., 2020). The cost-effective "CubeSat" satellites are also pivotal for space exploration and scientific missions, aiming to augment our understanding of diverse scientific domains such as astronomy, heliophysics, and planetary science (Saeed et al., 2020). International collaboration in space science and research is intensifying, with nations combining their expertise and resources. The indispensable role of governments in nurturing the space industry cannot be understated. State patronage facilitates the realization of avant-garde space technology and research, subsequently bolstering national defense capabilities (Wu, 2018).

The evolution and proliferation of space technologies have been pivotal in augmenting our understanding of the cosmos and yielding myriad benefits for humanity. The International Space Station (ISS) epitomizes this, serving as a nexus for cutting-edge technology and research, enriching domains from human health to global education and the burgeoning space economy (Emen, 2020). The horizon for space technology applications is vast and ever-expanding. However, the rapid expansion of space technologies has ushered in challenges, notably concerning space sustainability. For instance, the quandary of space debris has emerged as a focal point, with an estimated 300,000 potential satellite-destroying debris fragments in orbit (Emen, 2020). Addressing this conundrum necessitates concerted efforts, encompassing national and international regulations, and innovative solutions such as insurance incentives for debris mitigation (Harrington, 2020). In sum, space technologies, while offering a plethora of opportunities and benefits, also introduce challenges that mandate astute navigation.

The integration of generic technologies and components has been a game changer in the space sector, ushering in unprecedented capabilities and prompting even faster innovation. The incorporation of commercial off-the-shelf (COTS) technologies in satellite production epitomizes this shift, offering a blend of cost-efficiency and streamlined operations (Denis et al., 2020; Weinzierl, 2018). The rise of CubeSats underpinned by COTS components, and the advent of specialized suppliers focusing on cost curtailment through bulk production further accentuate this paradigm shift (Bi et al., 2022; Weinzierl, 2018). Another transformative approach is vertical integration, which combines service operation with satellite manufacturing, bypassing cumbersome contracting and procurement processes, thereby ensuring a seamless supply chain (Weinzierl, 2018). Concurrently, innovative manufacturing methodologies, such as additive manufacturing, are bolstering space capabilities (Bi et al., 2022; Weinzierl, 2018). However, the proliferation of these generic technologies and components is not devoid of challenges. Cybersecurity has emerged as a paramount concern in this context. Addressing these cyber vulnerabilities is imperative to safeguard the integrity and security of space systems (Bi et al., 2022).

3.4 Future Potential and Key Success Factors of the New Space Economy

The space economy is undeniably vast and comprises diverse segments, each with its unique potential for growth and impact. Navigating the intricate boundaries that sometimes delineate these segments can be a formidable task. In the following section, we will outline the most promising segments, drawing from our review of the existing literature.

Our analysis reveals that satellite constellations represent pivotal arenas for future growth, underpinned by technological evolution and the mounting demand for satellite services. The proliferation of satellite constellations, the inclination toward compact satellite missions, and the integration of these advancements with terrestrial networks set the stage for transformative economic growth. The management and optimization of satellite deployment in various orbits is a critical aspect of space operations. The future of this segment is tied to the advancement of technologies that enable a more efficient use of orbits and the development of smaller, more capable satellites. Growth in this segment will likely be driven by the increasing demand for satellite services, from communication to Earth Observation (Barry & Alfaro, 2021; Lambakis, 2018). The recent surge in proposed constellations—over a hundred in 2020—signals both the growth and unpredictability of this segment (Letellier & Lizy-Destrez, 2022). While high-orbit satellites predominantly hail from industry giants, LEO constellations expand their reach, catering to diverse environments, including the Arctic (Hoyhtya et al., 2022). The global trend leans toward smaller satellite missions epitomized by projects such as Starlink, which boasts over 2000 satellites. Moreover, the pursuit of small satellite launchers stems from increasing satellite counts and the blossoming of large constellations, which generated $1.2 billion investment between 2000 and 2016 (Ali et al., 2020; Denis et al., 2020). Enhanced electronics miniaturization which reduces satellite size and launch costs, augments this progression without compromising performance. In summary, the future of the space economy seems to hinge on LEO innovations, vast constellations, and compact satellite technologies, promising transformational growth and integration between satellites and terrestrial technologies.

Space technologies encompass a broad range of systems and applications. From satellite technologies to space-based sensors and instruments,

these technologies underpin the capabilities of the space economy. Technological advancements and the increasing demand for space-based capabilities will shape the future of this segment (He, 2022; Jakhu et al., 2020). Space technologies are poised for extensive and multifaceted advancements. The industry is transitioning toward more interconnected, decentralized systems of systems (SoS), fueled by the imperative of efficient information integration, which is crucial for mission success (Bi et al., 2022). Industry leaders notably advocate for the integration of space and terrestrial networks, especially for applications like remote 5G backhauling (Denis et al., 2020). With milestones such as SpaceX's Crew-1, the paradigm of space travel is shifting, urging NASA (and other governmental institutions) to adapt its strategies to foster public–private collaborations (McCaffrey, 2021). The US Department of Defense (DoD) continues to leverage commercial procurement, anticipating that this trend will intensify. Private ventures are also eyeing innovative space segments, from Martian research to space tourism, with potential planetary protection implications (Profitiliotis & Loizidou, 2019a, 2019b). Simultaneously, a significant proportion of individuals within the high-income bracket express interest in space tourism (Pásková et al., 2021). Conclusively, as the space sector evolves, it will likely become more interconnected and complex, amplifying the roles of private enterprises, and emphasizing public–private collaborations.

The space economy is poised for considerable growth, fueled by generic technologies that enhance space capabilities. Recent strides in democratizing space access, exemplified by SpaceX's reusable rockets, align with the miniaturization trend seen in satellites such as CubeSats, which are pivotal for global IoT connectivity (Bi et al., 2022; Denis et al., 2020). This transformation integrates space and terrestrial networks, heralding a new era of broadband access, especially in remote areas (Denis et al., 2020). The industry's pivot to satellite constellations demands novel, cost-effective manufacturing methods, championing standardized designs and expedited development (Eugeni et al., 2022; Rementeria, 2022). As lunar bases emerge as testing hubs for nascent technologies, from power generation to waste management, sensing technologies also rise in prominence for both terrestrial and space object tracking applications. With further space explorations, the surging data is bound to underscore the importance of continual space tech innovations (Bi et al., 2022). Fundamentally, propulsion systems, communication modalities, and advancements in materials science serve as the foundation

of this booming space economy, driving unparalleled economic growth and fostering innovation (Barry & Alfaro, 2021; Lambakis, 2018).

Space exploration, which encompasses, e.g., human spaceflight, robotic studies, and potential colonization, is a key driver of the future space economy. Companies like Blue Origin and SpaceX, with their ambitious plans, catalyze investments and technological advancements in this domain (Barry & Alfaro, 2021). There is growing attention toward mining resources from celestial bodies such as asteroids and the Moon, underlined by significant private and governmental interest (Feichtner, 2019; Marçal Sanmartí, 2020; Vergaaij et al., 2021). However, under the current framework of international and domestic law, considerable ambiguity exists regarding the legal parameters and guidelines for lunar and asteroid mining activities (Anderson et al., 2019; Steffen, 2022). Satellite technologies play an instrumental role in enabling such ventures, although their economic feasibility remains a subject of debate (Jakhu et al., 2020). The trajectory of this segment is influenced by scientific intrigue, evolving technology, and aspirations to broaden human activities in space (He, 2022; Szocik, 2019). Asteroids could soon bolster astronaut missions in multiple ways. They could serve as resource hubs for deep-space settlements, act as testing grounds for pioneering technologies, and even function as depots or transit vehicles for interstellar journeys (Krolikowski & Elvis, 2019).

Space transportation, which is pivotal to the burgeoning space economy, is driven by cost, delivery time, and technological risks (Denis et al., 2020; Rementeria, 2022). New entrants are reducing launch expenses, and SpaceX's reusable rockets exemplify these advancements. The increasing presence of specialized launch services, such as the deployment of small satellites from the ISS, further underscores this transition (Denis et al., 2020). Countries such as the United States and China have fortified their positions through a blend of government policies and private ventures. The push for commercial launches shows expansive growth in this realm (Pomeroy et al., 2019; Rementeria, 2022). However, despite varied solutions, space transportation remains under significant governmental influence, emphasizing the importance of domestic upstream capabilities. Ultimately, as the segment serves defense, communication and exploration needs, the urgency to advance technology and ensure security grows, underscoring its role in shaping the space economy's future trajectory.

Satellite communications are a segment that has already demonstrated its economic value and is poised for further growth. The demand for reliable and readily available high-speed communication services is growing, and satellite technology is uniquely positioned to meet this demand. The future of this segment will likely be shaped by the development of new technologies and the expansion of services to underserved areas (Jakhu et al., 2020; Lambakis, 2018). Essential to our digital era, these services foster global connectivity, are indispensable to defense, security, and commercial ventures (Lambakis, 2018). Both commercial and defense sectors are increasingly reliant on satellite capabilities (Budning et al., 2021; Lambakis, 2018). The incorporation of 5G/6G into satellite systems signals is a transformative change, offering the benefits of decreased communication delays and an edge over conventional geostationary orbit (GEO) systems (Hoyhtya et al., 2022; Jha et al., 2022; Saeed et al., 2021). Mega constellations such as Starlink further redefine this landscape, complemented by shared ground station networks such as Amazon AWS that centralize data from numerous satellites (Jha et al., 2022). While the potential is immense, this burgeoning reliance calls for heightened security and resilience. Efforts encompass space debris mitigation, secure connectivity systems, and strategies to counteract satellite interference (Hoyhtya et al., 2022; Jha et al., 2022; Lambakis, 2018). The future of satellite communications includes governmental satellite communication solutions, which integrate 5G/6G technologies with security features and quantum solutions (Hoyhtya et al., 2022). Satellite communication's future is vibrant, central to the expanding space economy. Embracing novel technologies, fortifying security, and championing sustainability and regulations will cater to the escalating needs of diverse sectors.

Earth Observation (EO) is a segment with significant future potential. The ability to monitor and collect data on the Earth's physical, chemical, and biological systems have wide-ranging applications, from climate monitoring to disaster management. The growth of this segment is expected to be driven by the increasing demand for data and the advancement of satellite technologies (Argentiero & Falcone, 2020; Budning et al., 2021). The analysis underscores the importance of EO satellites for providing valuable data for various Earth applications, from environmental monitoring to urban planning. Similarly, scientific research in space will continue to lead to numerous technological and scientific advancements, contributing to the growth of the space economy.

4 Conclusion and Further Research Directions

Based on the analyzed literature, it can be noted that the emergence and phenomenal growth of the space economy cannot be attributed to a single or even a few factors. It is rather a complex, multifaceted phenomenon, intricately woven by technological advancements, governmental patronage, and the strategic imperatives of defense applications, that at a later stage have been supported more and more through purely civilian commercial projects. The governmental backbone has been instrumental, providing not only financial but also infrastructural and moral support, catalyzing the sector's growth and ensuring its sustainability. The space economy functions like a self-sustaining reaction, where the demands of one field catalyze the substantial development of others. This interconnectedness makes it challenging to pinpoint a singular cornerstone of the space economy.

In this study, we observed from the literature that defense imperatives, technological advancements, and burgeoning commercial interests are the main catalysts for growth. Historically, the quest for enhanced surveillance, reconnaissance, and communication capabilities has driven nations to invest significantly in space technology and exploration. These early investments, initially spurred by pioneering aspirations and technological curiosity, have matured over time into indispensable tools for national security. This evolution underscores the strategic importance of space within the broader canvas of global geopolitics. At the same time, we are seeing an unprecedented democratization of space, through purely private and civilian initiatives. These mainly commercial activities are taking the previously defense-centric space economy toward new horizons and leading to a transformative evolution of the space economy. However, this journey is interspersed with challenges. The increasing militarization of space, the looming threat of its potential weaponization, and the ever-present concern of space debris necessitate a framework of robust governance, stringent regulation, and international collaboration.

The commercialization of space emerges as a transformative theme in this study. Based on the reviewed literature, transitioning from traditionally government-led initiatives to a more commercial-centric paradigm, the space sector is witnessing a reshaping of its very fabric. At the heart of this commercialization, and the ensuing democratization of space, is the development and proliferation of space-centric products and services tailored for diverse commercial markets, usually entirely outside of the

space domain. This evolution is not only reshaping the industry but is also anticipated to ignite competition, foster unparalleled innovation, reduce operational and entry costs, and unveil novel economic growth avenues. The ripple effects of this transformation are profound, with expectations of substantial job creation, a surge in innovation, and a plethora of opportunities for both established businesses and budding entrepreneurs.

Moreover, the space sector is witnessing a technological renaissance. The fusion of space-specific technologies with generic, terrestrial technologies is expanding the realm of possibilities in space. Pioneering innovations, such as the development and deployment of LEO constellations and the rise of small, versatile satellites, are revolutionizing traditional communication and surveillance capabilities. The democratization of space, further propelled by commercialization, promises to catalyze innovation, broaden participation, and amplify the collective benefits of space activities, setting the stage for an era of inclusive, global space exploration.

In light of these developments, the absence of a dedicated theoretical framework for the space economy becomes increasingly conspicuous. While existing theories provide initial scaffolding, they fall short in addressing the unique complexities of space activities, such as technological challenges, ethical considerations, and international regulations. The development of a bespoke theoretical framework is imperative for targeted research and effective policy formulation. This would not only deepen our understanding of business dynamics in the space economy but also facilitate more robust strategies and cross-border collaboration.

As we stand at the crossroads of the future of the space economy, the landscape offers a rich tapestry of opportunities, intricately woven with challenges. As we navigate this multifaceted landscape, a harmonized, collaborative approach is paramount. This approach, which balances both the potential and inherent complexities of space endeavors, co-operation will be instrumental in ensuring the holistic, sustainable, and beneficial evolution of the global space economy.

4.1 Further Research Implications

The space economy, with its vast opportunities contrasted against inherent challenges, offers a fertile domain for both academic and practical exploration. The analysis of the literature reveals a predominant alignment with the definitions presented in the 2nd edition of the OECD

Handbook on measuring the space economy. The importance of understanding the present state and prospects of national space economies, as delineated in the OECD Handbook, cannot be overstated, as it provides a comprehensive overview of a nation's space economy potential.

This article consistently underscores the strategic significance of defense in space. Historically, investments in space, driven by defense imperatives, have been catalysts for technological and infrastructural advancements that have shaped the trajectory of the space economy. Nations' defense and military priorities have deeply influenced the evolution and growth of the space economy. At the same time academic literature seems to see the future potential more in other segments of the space economy, suggesting that a change might be upon us in this regard, and understanding this shift might prove to be crucial. It is notable, that the segments that have defined the space economy since its beginning days, such as defense, PNT or space exploration are not at the forefront of future expectations, even though their importance and potential remain high.

The literature that we have referenced seems to highlight the increasing role of the private sector in space activities. Their involvement has yielded innovative approaches, increased financial commitments, and initiated a shift in the conceptualization and realization of space missions. While, e.g., the domains of space tourism and space mining are not exhaustively explored in this article, the growing engagement of the private sector advocates a promising trajectory for these and other areas. The innumerable benefits that space exploration offers, from scientific advancements to potential space habitation, further highlight the potential of these new kinds of ventures.

While potential avenues for future research are endless, based on our findings the following areas of research seem to be the most urgent for understanding the whole potential and challenges of the space economy:

- What are the foundational principles and theories that can be developed to understand international business in the context of the space economy?
- How has the OECD Handbook on measuring the space economy been implemented in statistical reporting, and are there discernible differences between countries in terms of space industry development and internationalization opportunities?

- What specific barriers to market entry do companies encounter when expanding into various national space economies, and how do these barriers differ across countries?
- How can a multidisciplinary approach, incorporating international economics, provide a more nuanced understanding of the complexities inherent in the space economy?
- What insights can case studies offer into the economic strategies employed by different countries and companies in the space sector?
- How do different national policies and economic strategies in the space sector compare in terms of effectiveness and impact on the global space economy?
- How is the dynamic between defense and security in space, particularly in the context of increasing commercialization developing?
- What is the role and influence of start-ups in driving innovation and competition within the space sector?
- What challenges and opportunities are presented by LEO constellations and the emergence of small satellites?
- How does the integration of terrestrial technologies into space applications affect the broader technology sector?
- What strategies can be developed to enhance international collaboration and ensure the sustainable and collaborative use of space resources?

Moreover, the imperative for research in international economics as it pertains to the space economy is increasingly evident. Topics such as market entry strategies across different national space economies, the implications of international space law on global trade, and the role of international taxation and financing mechanisms are becoming ever more important when assessing the viability and holistic impact of future space endeavors. These economic considerations are integral to understanding how the space economy interfaces with global, non-space-related markets, and regulatory frameworks, thus likewise affecting how space capabilities are developed. A multidisciplinary approach, incorporating especially international economics, is therefore indispensable for a nuanced understanding of the space economy. This focus on international economics not only enriches existing research agendas but also serves as a critical lens through which to explore the complex interplay between space activities and global economic systems.

At a broader scale our findings also emphasize the need for robust regulatory frameworks to ensure sustainable and equitable access to outer space while addressing potential conflicts and resource conservation. The rising prominence of the private sector, the extensive benefits of space exploration, and the imperative for international collaboration are other key themes that resonate throughout the article's narrative.

4.2 Limitations

As this study operates at the cutting edge of economics-focused new space research, we recognize the potential for imperfections in our selection methodology. Our analysis should be perceived more as a broad exploration and synopsis of the factors shaping the growth of a sustainable (new) space economy and its future, rather than a comprehensive listing of all related works. However, the 72 international academic papers ultimately chosen for our literature review epitomize the most pivotal contributions in this academic domain. While our selection was not entirely exhaustive, it encompasses a substantial and highly indicative collection of scholarly efforts, underscoring the growing attention and significance this subject now commands within the global academic sphere.

We also wish to acknowledge the subject's complexity and novelty and emphasize that the framework we have used in this paper to classify activities within the new space domain is not fully exhaustive. Thus, we see an urgent need for developing a framework that better describes the different levels and relationships of activities not only within the space economy, but also the linkages to the broader, global economy. We also acknowledge that a large amount of the used literature was US-based, though this was also to be expected due to the prominence of the US in the space domain and was not an active choice from the authors. Due to the factors mentioned above, it was quite challenging to construct a comprehensive categorization for "new space" activities.

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