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Space Economy Research Trends for Foresight Analysis

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ABSTRACT

A recent economic sector, the space economy, has been the subject of discussions at several international events, including the G20, COPUOS, and the World Economic Forum. The evolution of space activities from the traditional space era to the New Space era influences market shares in the global economy. This study aims to identify trends in space economics studies conducted up to 2023. The study used the Google Scholar database with space economy and valuation size of space economy as keywords. Further bibliometric analysis was conducted using VOSviewer, Publish or Perish, and then artificial intelligence (AI) (ChatGPT). The study aims to identify the current direction in space economy research in terms of its subjects, issues, innovation, and publishing output. In addition to global trend research, a study was carried out on the space economy in Indonesia. However, the amount of research on the space economy in Indonesia, however, is still very limited in terms of case studies, which restricts a comprehensive description of the Indonesian space sector and industry. The research also shows how the space economy, as a sector, contributes to creating income for the economy.

Keywords: Space economy; Research trend; Bi-bibliometric; New Space era; Space sector.

INTRODUCTION

Space is a region with both military and civilian applications and strategic value. In recognition of the dual-purpose nature of space, high-tech and costly products and services are classified as quasi-public goods or strategic goods (Know.space 2023). According to the World Economic Forum (2022), the space economy involves the production of products and services in space and for space, including research, exploration, manufacturing, and value-added activities (OECD 2022). In economic theory, space activities include production, consumption, and distribution activities to produce space products and services (research, manufacturing, and services) that generate income and expenses for the purchase of capital goods, involving governments, space agencies, the private sector, the public, and international economic actors.

Space technology products are utilized in the downstream market, in applications (OECD 2022) such as navigation, telecommunications, and remote sensing. The evolution of space activities from the traditional space era to the New Space era has had an impact on the space economy. Initially, space exploration was dominated by government actors; currently, it has shifted toward ever-increasing private involvement. The private sector has derived business opportunities from space activities (Brukardt 2022). The space economy continues to grow and transform into an economic sector (ESA 2019). It is integrated into current pillars of development, namely space society, space diplomacy, and the space economy itself. The space sector has stimulated the growth of other sectors. Thus, it is not only a growth sector in itself but also a vital enabler of growth in other sectors, which are predicted to become industries capable of generating millions of dollars in the 2040s (ESA 2019).

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The implementation of space activities in Indonesia itself has been ongoing since 1960 and has undergone several institutional transformations. Indonesia issued Space Act Number 21 in 2013, which defines space activities as access to outer space, development of space technology (rocket, aeronautics, satellite), development of applications in remote sensing, spaceport operation, and commercialization. The Indonesian space program follows a roadmap from 2017 to 2039, and the National Long-Term Development Plan – Rencana Pembangunan Jangka Panjang Nasional (RPJPN). The launch of a national rockets and satellites by the private sector demonstrates private participation in space investment alongside the government. During the 1960s, Indonesia launched commercial satellites for telecommunications and banking activities. Data on the economic effects of space activities in Indonesia are currently limited due to the need to assess and track the effects of expenditures on space activities in Indonesia from both public and private entities. Numerous recent publications lack a uniform method to measure the space industry as a whole.

Meanwhile, the development of the space economy has gained increasing global attention, as it contributes significantly to economic growth, technological innovation, and geopolitical dynamics (UNOOSA 2021). According to the Space Economy at a Glance report, the global space economy exceeded USD 400 billion in 2020 and is projected to surpass USD 1 trillion by 2040 (BryceTech 2023).

According to previous publications, the global space economy is undergoing rapid expansion, with 2023 marking a record 223 orbital launches – dominated by LEO deployments and commercial constellations (SpaceWorks 2023). Commercial activities now account for 80% of the USD 570 billion global space economy, projected to reach USD 2 trillion by 2040, driven by reusable launch systems, in-space manufacturing, and cislunar logistics (PwC 2025). Earth observation, valued at USD 5.1 billion, is growing steadily through AI-enhanced applications in agriculture and climate resilience (Grand View Research 2024). Despite a 46% drop in startup investment (BryceTech 2023), innovation continues through CubeSat proliferation and regional missions, especially in South America (Dallamuta *et al.* 2023; Kulu 2024). The OECD (2023) highlights rising satellite counts and infrastructure dependence, while space debris and regulatory gaps pose strategic risks. These trends underscore the need for structured bibliometric foresight to map thematic evolution, innovation trajectories, and global participation in space economics. As the space economy expands, so does the volume of academic research seeking to understand its technological, economic, and policy dimensions. However, the intellectual structure of space economics as a research domain remains fragmented.

Existing studies tend to focus on specific subfields such as satellite markets, space law, or commercialization without offering a comprehensive mapping of how the field has evolved. Almeida and Silva (2021) conducted a bibliometric analysis of space economy literature and identified three dominant clusters: technology, policy, and commercialization. Moreover, there is a notable absence of studies that systematically analyze space economics literature using longitudinal bibliometric techniques to identify trends in subjects, issues, innovation trajectories, and publishing output. Most existing research lacks integration between bibliometric mapping and foresight methodologies, resulting in limited utility for strategic planning and policy formulation. This gap is particularly significant for emerging space nations such as Indonesia, where understanding global research trajectories is essential for aligning national priorities, strengthening research capacity, and identifying strategic opportunities.

However, research on the space economy remains relatively limited, particularly in developing countries such as Indonesia. Indonesia is entering a critical phase in space development, with increasing interest in satellite technology, Earth observation, and space-based services. However, the country lacks a comprehensive foresight strategy to guide its participation in the global space economy. Bibliometric foresight can help bridge this gap by revealing Indonesia's research positioning, identifying strategic opportunities, and informing policy directions that support sustainable and inclusive space development.

This study aims to explore the thematic evolution, geographic distribution, and publication trends in space economy research from 1949 to 2023, focusing on the differences between the traditional space era and the New Space era. This study aims to develop a bibliometric-based foresight framework to analyze global and Indonesian trends in space economy research. By mapping thematic evolution, institutional contributions, and innovation trajectories, the research provides actionable insights for science, technology, and policy stakeholders. This study employs a bi-bibliometric technique with keyword analysis and co-citation analysis of paper citation data to investigate research trends relevant to space economics, and then uses artificial intelligence (AI) tools such as Scopus and ChatGPT to identify current trends and forecasts of the space economy are from several documents. By surveying the research areas of all researchers worldwide (González-Albo *et al.* 2010) and current trends (Daim *et al.* 2005), bi-bibliometrics is expected to provide an overview of researchers' activities, including research subjects, areas of interest, and journal sources (Pendlebury 2008). Since the volume of research on the space economy in Indonesia is rather limited, the objective of this study is to analyze global research trends, as well as current trends and forecasts for the future.

Literature review

The space economy has gained increasing scholarly attention over the past 2 decades, reflecting its growing role in global innovation, infrastructure, and policy. Defined by the OECD (2022) as "the full range of activities and the use of resources that create and deliver value and benefits to human beings in the course of exploring, understanding, and utilizing space," the space economy spans upstream sectors (e.g., satellite manufacturing, launch services), midstream operations (e.g., ground infrastructure), and downstream applications (e.g., Earth observation, space-based analytics). As this domain expands, academic literature has attempted to capture its complexity through various disciplinary lenses, including economics, technology studies, and policy analysis. As space-based technologies increasingly intersect with terrestrial sectors – such as agriculture, climate resilience, and digital infrastructure – the space economy has become a strategic pillar of national innovation and competitiveness. However, its academic representation remains fragmented, with limited synthesis across disciplines and inconsistent terminology. This conceptual ambiguity underscores the need for structured mapping and trend analysis to clarify the intellectual landscape of space economy research.

Bibliometric analysis has emerged as a powerful method for mapping scientific knowledge, identifying thematic clusters, and tracking innovation trajectories. Zupic and Čater (2015) argue that bibliometric methods are particularly effective in emerging fields where conceptual boundaries are still forming. Tools such as VOSviewer enable the visualization of keyword co-occurrence networks and thematic evolution, while Publish or Perish facilitates citation analysis and author productivity tracking (Harzing 2007). In the context of space economy research, Almeida and Silva (2021) conducted a bibliometric study using Scopus data and identified three dominant clusters: space technology, commercialization, and governance. Their work provided a foundational overview but was limited in temporal scope and lacked integration with foresight methodologies. Cunningham and Porter (2022) extended the analysis by incorporating patent data to examine technology emergence; however, their study did not explore thematic evolution or regional disparities in publishing output. Other contributions have focused on policy and investment perspectives. For instance, the OECD (2022) and NASA (2024) offer macroeconomic assessments of space activities, while the World Economic Forum (2022) highlights private-sector growth and regulatory challenges. However, these reports are descriptive and do not systematically analyze academic research trends or innovation dynamics. This study addresses the above limitations by conducting a comprehensive bibliometric analysis of space economy literature published until 2023. It integrates VOSviewer and Publish or Perish to map keyword trends, citation networks, and institutional productivity. Scopus AI analytics are employed to detect emerging topics and visualize thematic evolution. By synthesizing these insights within a foresight framework, the study aims to identify dominant and emerging themes in space economy research, assess innovation trajectories and publishing output across regions, and evaluate Indonesia's research positioning and strategic relevance.

METHODOLOGY

This study employs a mixed-methods bibliometric and content analysis approach to identify and analyze emerging trends in the space economy. The methodology consists of several key stages: data collection, data filtering, bibliometric mapping, and qualitative interpretation. The study draws on bibliometric and content analysis techniques to identify key themes, influential authors, and emerging research clusters in the field. The main elements of the methodological framework used in this research are as follows:

Data collection

- Sources: Academic publications were retrieved from Scopus and Google Scholar using the Publish or Perish tool (Harzing 2007).
- Time range: 1947-2023
- Keywords used: "value size of the space sector."
- Export format: data were extracted in .csv and .ris for use in bibliometric software.

Filtering process

Duplicates and non-relevant articles were removed based on titles and abstracts. Only English-language and peer-reviewed publications were included. Articles with fewer than five citations were excluded to prioritize scholarly impact.

Analytical tools and techniques

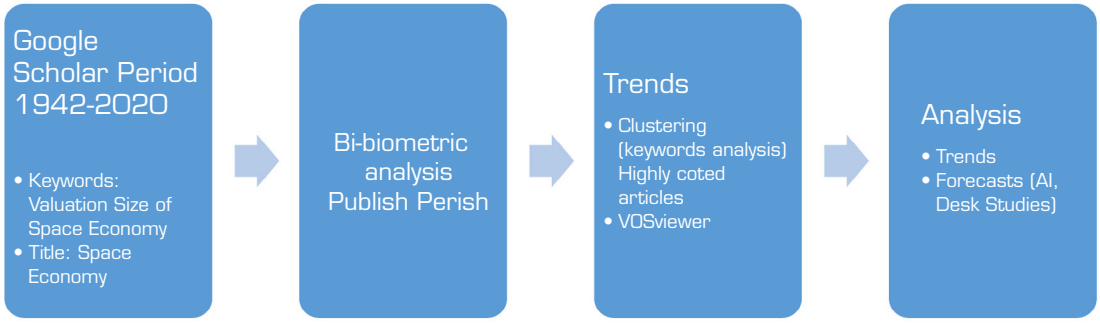
- VOSviewer (van Eck and Waltman 2010)
- Used to visualize co-authorship, keyword co-occurrence, and citation networks.
- Identified thematic clusters such as:
- Publish or Perish
- Supported citation-based filtering and author-level impact analysis.
- Generated citation metrics (e.g., h-index, g-index) for core literature such as:
- AI (AI Scopus, Microsoft Copilot, ChatGPT)
- Used for trend analytics, including:
- Annual publication output
- Top subject areas
- Leading institutions and countries
- Provided insights into growth patterns and international collaboration.

Interpretation and synthesis

- Cluster analysis from VOSviewer was matched with citation patterns and manually reviewed abstracts to interpret trends.
- Thematic synthesis was developed around emerging subfields, policy relevance, and industrial applications

In this study, global trends in space economy research using search phrases such as "value size of the space sector" were analyzed. The VOSviewer software developed by Leiden University was employed to create the association map on VOSviewer. A map based on the co-occurrence matrix table was used to show author information, citation relationships, and keywords. Bi-bibliometric analysis is currently used to analyze research trends (Daim *et al.* 2005), to identify emerging areas of science, and to determine where and how often specific articles are cited (Pelicioni *et al.* 2018). It is also used to identify and analyze data, including books, articles, and other publications, or to map the scientific activity in specific research areas, including the space economy, which is the object of the present research (Pendlebury 2008). In this study, publications up to 2023 were surveyed using the Publish or Perish software with specific keywords, and then performed analysis was performed with the VOSviewer. AI Scopus was then applied to identify what are the trends and forecasts for the space economy. Publish or Perish is a software program dedicated to the retrieval and analysis of academic citations, using different citation metrics (total number of papers, citations, etc.) (Harzing.com 2025). Data from books and publications were processed into publication maps displayed in various formats and functions, such as zooming, scrolling, and searching, through the VOSviewer software, which presents bibliometric graph maps in an easy-to-interpret manner (Shah *et al.* 2019).

The use of AI continues to evolve in the space sector. NASA (2024) employs AI across several mission areas, including advanced data analysis for scientific discovery. The use of AI is rapidly transforming space research, space exploration, space education, and other related areas (Barney 2024). Figure 1 schematically shows the steps followed in the present research.



Source: Elaborated by the authors.

Figure 1. Research steps.

RESULTS

By employing bi-bibliometric analysis, it is possible to identify potential directions for the new space economy research using the VOSviewer and Publish or Perish-related space economy themes with keywords. It can show about global space economy topics, keywords, and the number of publications related to the space economy, and suggest potential growth directions for new space economy research.

Keyword analysis

Figure 2 shows a density-based association map of 33 keywords (from the collecting data) used in space economy research obtained through a VOSviewer map. Association keywords that have emerged include space sector, value chain, space industry, evolution, political economy, global space economy, service, and new space economy. According to the results, keywords that frequently appear in publications are shown in intense yellow and include resources, political economy, role, and global space economy. Keywords that are still used but less frequently, such as sector, digital economy, space industry, and case study (see Fig. 2), are represented by light yellow density images.

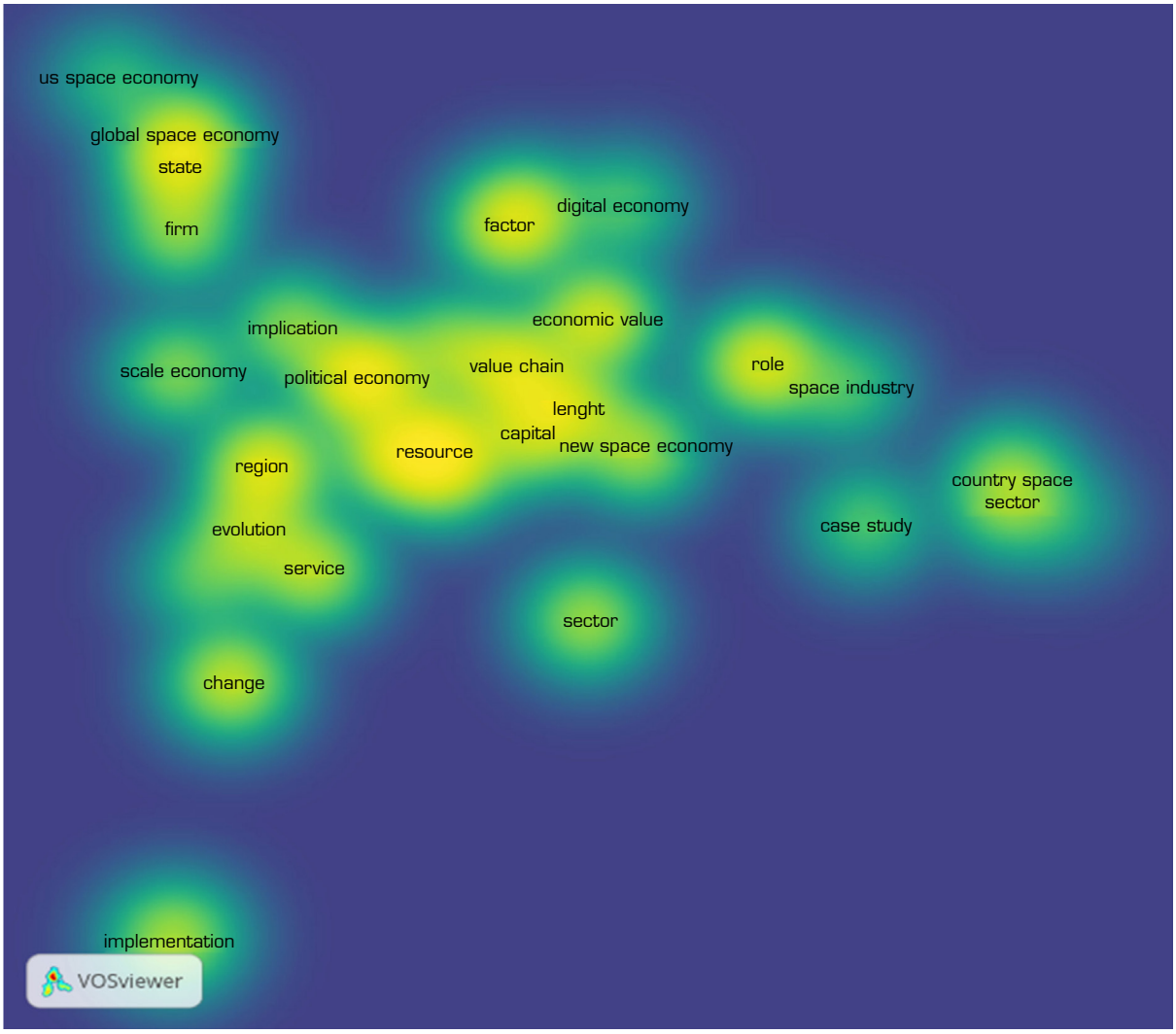


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Figure 2. Density-based association map.

Figure 3 shows six research clusters that are connected to the term "space economy" with an accuracy score of 4 from a VOSviewer map. To differentiate them, the clusters are colored in various shades of yellow, purple, light blue, dark blue, pink, and green. The keywords "space industry, country, role, sector," and "case study," represented in green in Fig. 3, are frequently used in research linked to the space economy and the space sector (see Fig. 3 and Table 1). This result appears in analyses associated with the keyword new space economy, which in turn emerges in connection with the same term.

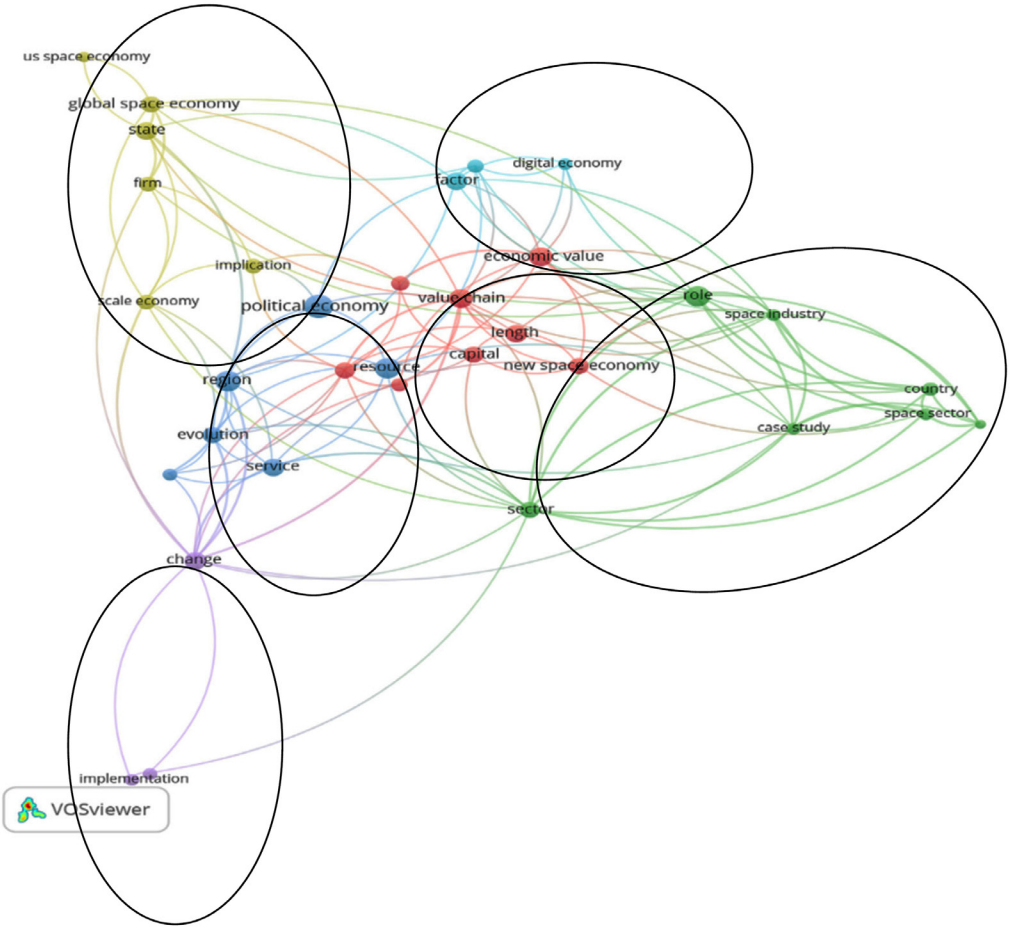

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Figure 3. Cluster of keywords from research on space economy trends.

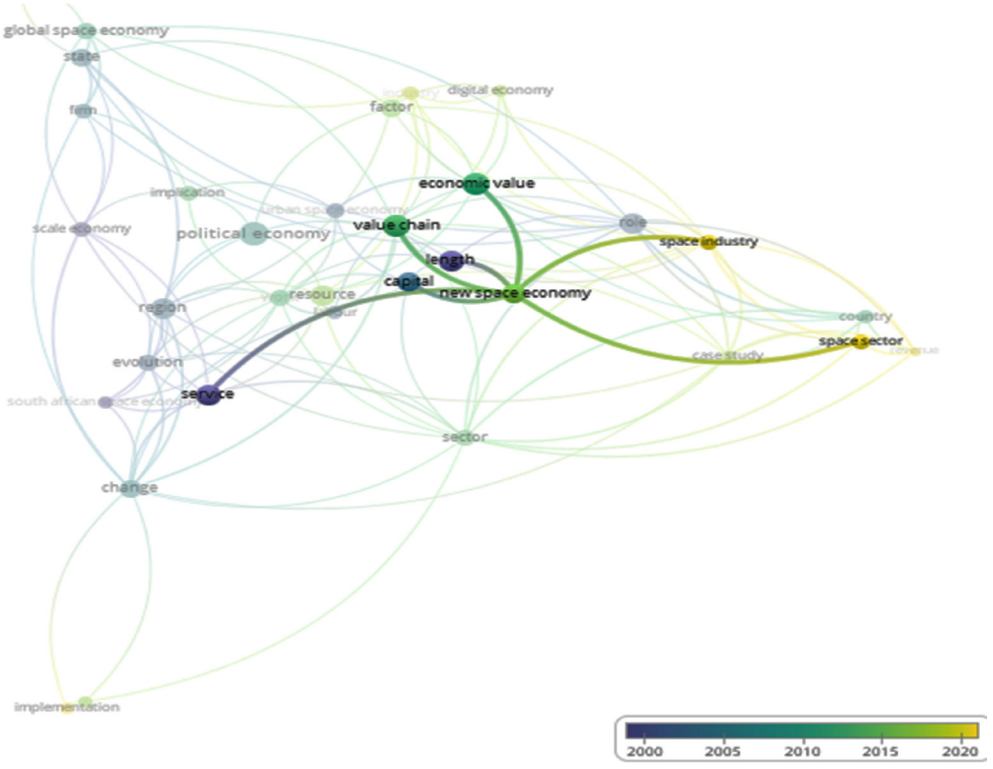
Table 1. Clusters of space economy research (relationship between the clusters listed in the table and their colors in the figure).

1 (red color)	2 (green)	3 (dark blue)	4 (yellow)	5 (purple)	6 (light blue)
(8 items)	(7 items)	(6 items)	(5 items)	(3 items)	(3 items)
Capital Economic value Labor Length New space economy Urban space economy Value chain Work	Case study Country Revenue Role Sector Space industry Space sector	Evolution Political economy Region Resources Service South African space sector	Firm Global space economy Implication State U.S. space economy	Change Implementation Sustainability	Digital economy Factor Industry

Source: Elaborated by the authors.

Based on the mapping of cluster 1, marked in red, publications on the topic of the space economy mostly refer to the keywords value chains, new space economies, capital, and economic value. Research on the new space economy based on economic value, represented by the largest circle, is one of the most studied topics. This has become a source of citations for research in cluster 2 (green), which then appeared in the 2015-2020 period with studies that began to extensively discuss the current role of the space economy (dominating) and started to explore the space industry and space sector, which remain relatively limited in the number of publications.

The network map (Fig. 4) illustrates the color differences associated with the subject of space economy research. The yellow color represents research that started from 2015 to 2020 in the areas of space industry research and the space sector. This corresponds to the industrial revolution and the institutional transformation from the traditional to the new space period, which includes the introduction of the private sector into space operations. Pelton (2019) introduced the concept of "Space 2.0," referring to a new era in the space industry characterized by active private sector participation, reduced launch costs, and increased accessibility to space. These developments have opened new opportunities for exploration, research, and commercial applications in space.

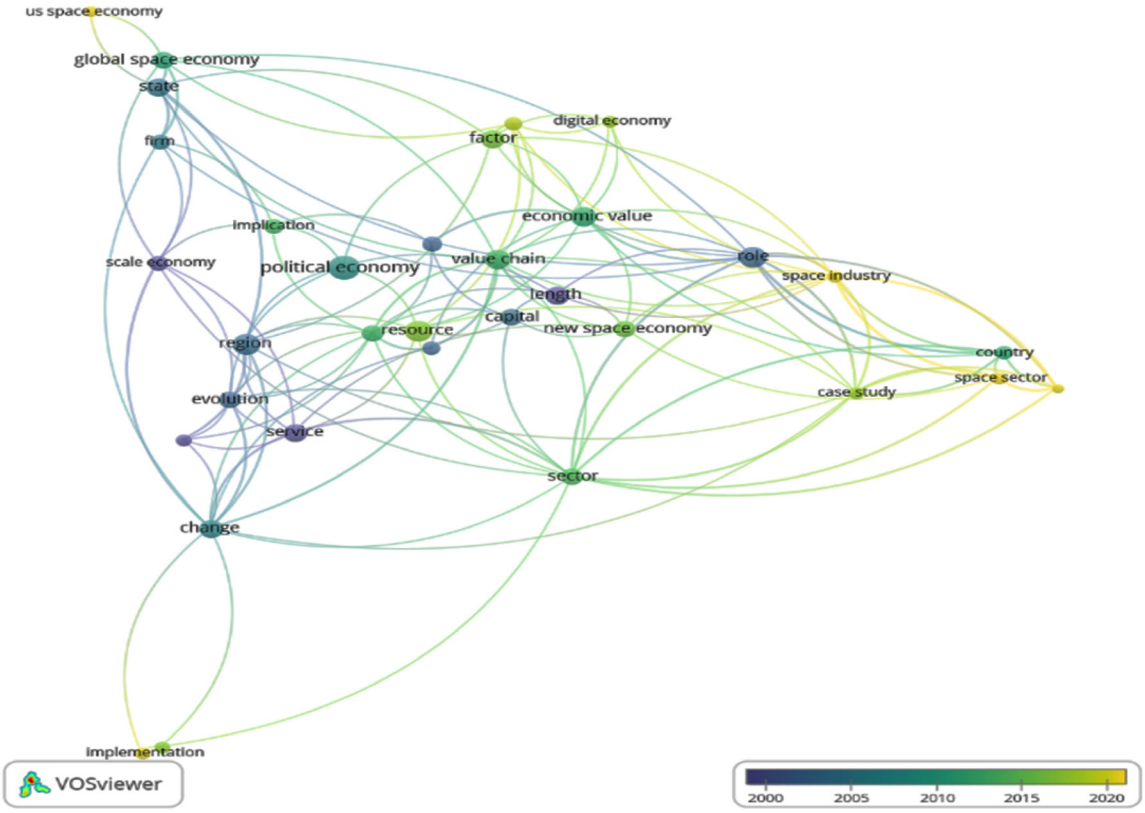


Source: Elaborated by the authors.

Figure 4. Map of the network.

Visualization of the space sector topic

Research related to the space industry, or space sector, is a new theme emerging in the period from 2015 to 2020, as shown in Fig. 5. One of the challenges in measuring the space sector involves considering revenue as an indicator of space economic activity, a fact that has been noted in several case studies. This research is relatively new and refers to biometric analysis; at least the theme related to the space economy has emerged at the earliest in 2015 with the new space economy trend, which includes publications with the theme of space, especially the space economy, are among that are still rare and limited in number. Some of the top international journals that are referenced for publication display titles such as Space Policy, New Space, Geographic Compass, Astropolitics, as well as journals related to management, planning, economics, geography, aerospace, and politics. This corresponds to increasing space awareness and public interest in space activities. The ESA (2019) mentions that the New Space and its still-growing space industry are undergoing further development.

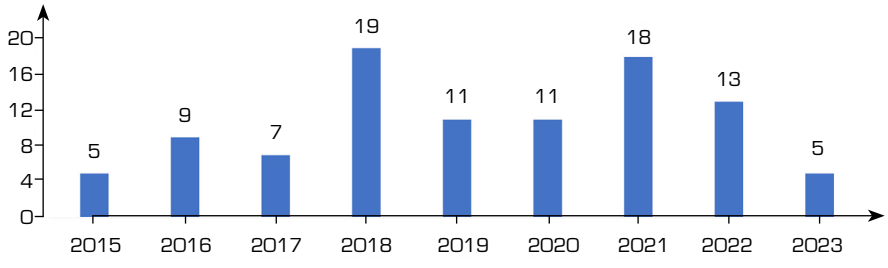


Source: Elaborated by the authors.

Figure 5: Research map related to the space industry and the space sector.

Publications related to space economy research from 2023 received a total of 15,762 citations, with an average number of 213 citations per year and 78 citations per paper. This set of publications has an h-index of 47 and a g-index of 124 (analyzed using Publish or Perish). The transformation of the space economy from the traditional era to the New Space era has led to an increase in the number of publications from 2015 to the present. This corresponds to the involvement and increase in the number of private actors in space activities, in addition to public actors.

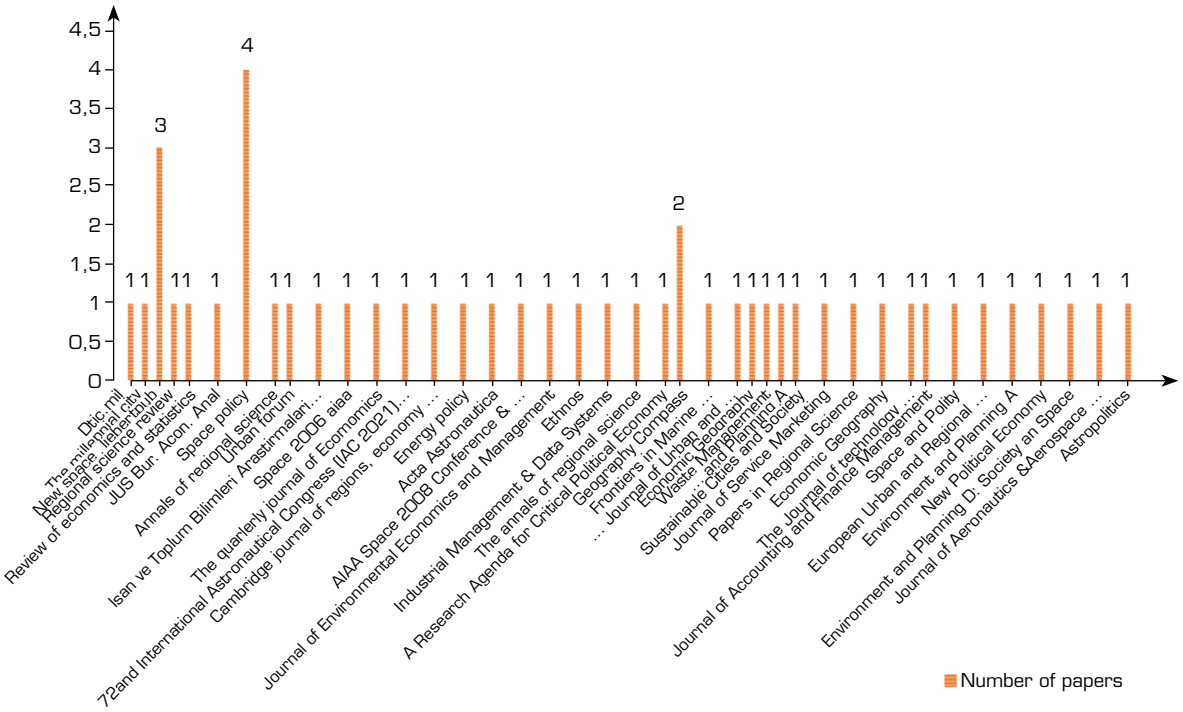
Figure 6 shows the distribution of publications by year from 2015 to 2023, and it can be observed that space economy research is a relatively new field with limited literature. This is supported by the frequency of space-related publications, which are often confined to journals and proceedings with varied scopes. The growth trend in the number of publications continues to rise annually from 2015, peaking at 19 papers in 2018.



Source: Elaborated by the authors.

Figure 6. Number of publications from 2015 to 2023 related to space economy and valuation size of space economy by distribution of paper.

Publications on the topic of space, especially space economy, are among those that are still rare and limited in number. Some of the top international journals serving as references for publications on space-related themes include Space Policy, New Space, Geographic Compass, and Astropolitics. Other important journals for that matter are related to scope management, planning, economics, geography, aerospace, and politics (see Fig. 6). This reflects the increasing space awareness and public interest and investment in space activities. One of the journals that receives many articles related to the theme of the space economy is Space Policy (see Fig. 7). However, publications related to research topics in the space sector and the space industry constitute a new area of study that is still being explored.



Source: Elaborated by the authors.

Figure 7. Distribution of the number of publications and logistical papers related to the topic of the space economy.

Policymakers and regulators need data on space economic research in order to follow the change included by the current surge in the number of private entities and growing space commercialization activities. The increasing volume of investment from both public and private actors demonstrates this trend. The space economy is outlined as a major future trend in the Indonesia's RPJPN Draft for 2045, consistent with the rise in space activities for commercial purposes. From an economic standpoint, satellite clusters, space debris, and the Earth's orbit are common pool resources (Ostrum 2009, cited in Smith 2017), but there are several regulation and law or forums on ITU (2023) and UNOOSA (2018) to set regulation and discuss how to use the space region (included orbit) for peacefull objectives-in the long term. However, COPUOS (2018) highlights the fact that the Earth's orbit is a limited natural resource, which restricts how different analyses are conducted from a macro and micro economic research standpoint. Current space activities contribute significantly to the economy, as seen by the growing number of satellite launches into orbit, as well as space traffic and trade. The value of the global space industry has expanded rapidly each year since 2015.

At least this shows that space activities are a new and special sector with a long value chain from downstream to upstream and has a multiplier impact. The definition of the space economy itself continues to evolve in line with space activities. The New Space era has given rise to discussions regarding the space industry and the space sector. In economics, a sector is a collection of activities carried out by state or government actors, industry, society, and individuals in producing and consuming goods and services.

The space industry emerged from private involvement in space activities within the space economy, in a chain of activities (upstream to downstream). Therefore, the Space Economy Leaders Meeting (SELM) at the G20 forum raised the topic of the importance of the contribution of the space economy to the global economy.

Space Industry Meetings are one of the venues used to bring together business space across industries, from start-up companies to SMEs and the government. Apart from that, the space economy has been on the agenda in other international panels, such as UNOOSA, and has been included in Space 2030, namely the Space 4 SDG pillar, since 2018. These results are strengthened by bi-bibliometrics, where the discussion of issues related to the space sector and the space industry emerges within a multidisciplinary approach. Publications related to space economics, which discuss the space sector, are still very limited, and not much information can be found in case studies, descriptions of the space sector and industry, or research on the space economy globally. One of the novelties of existing international research is to show how to analyze the space economy as a space sector from the point of view of its contribution to creating income for the economy (gross domestic product [GDP]) (Highfill and MacDonald 2022). From bi-bibliometrics, it has been possible to indicate the direction of trends related to space economy research, where current research focuses on research interests, trying to reveal the valuation side by looking at the contribution of space economic activities through the creation of national income (GDP), employment creation, and economic impacts. This specific research is conducted through case studies and measurement of the sector from various approaches, such as politics, economics, policy or regulation, and cooperation

Case study: Indonesia

Research related to the space economy in Asia, including Indonesia, is still limited and challenging. This is demonstrated by the limited number of publications from the perspective of space economics as a special sector in Indonesia. Actually, space activities in Indonesia began with the establishment of the National Institute of Aeronautics and Space since Lembaga Penerbangan dan Antariksa Nasional (LAPAN) was built in the 1960s, and there are limited publications related to the space economy according to Scopus or Google sources. Indonesia also has a Space Act and derivative regulations, including the Roadmap for Space Activities 2017-2040. The literature review revealed a lack of data regarding the impact of economic growth indicators. Indonesia's roadmap specifies the following strategic goals:

- Indigenous micro-launch vehicle development.
- Development of nanosatellites for maritime, agriculture, and disaster monitoring.
- Collaboration with space-faring nations.
- Promotion of satellite-based economic services (e.g., e-farming, coastal surveillance).

Table 2 displays an assessment of the impact of the space economy in Indonesia. Indonesia has operated 30 satellites in orbit since 1976, with names such as Palapa AI, LAPAN A1/Tubsat, SS1, Satria 1, RIDU-sat, and now Nusantara Lima. Space activities in Indonesia are in line with global trends, including launch systems, space operations, ground station business, and data services. Indonesia is also operating telecommunication satellites and receiving remote sensing satellite data. The impact of connectivity issues on the digital economy is significant. The majority of space industries operate downstream.

Table 2. Space economy in Indonesia

First satellite in orbit	Palapa A (1976)
First satellite manufactured in orbit	Lapan A1/Tubsat (2017)
Number of active satellites in orbit	8
Total satellite launched	30
Number of spaceports	Pameungpeuk (existing location requiring revitalization); Biak (planned for 2029)
Institutional space budget	N.A.
Facilities	National Observatory in Timau (Kupang)
	Ground station in Biak (TTC), Pare-Pare (RS), Agam, and Rancabungur
	AIT facility (satellite production)
	Aeronautic facilities
Share to GDP	Rocket facilities (laboratory and production facilities) – N.A.

Source: Elaborated by the authors.

The current increase in the number of private actors and the growing commercialization of space activities promote the need for data for policymakers and regulators related to space economic research. This is shown by the increasing amount of investment from both public and private sectors. In the 2045 Indonesian RPJPN Draft, the space economy is a megatrend for the future, and this corresponds to the increase in space utilization activities for commercial purposes. From an economic perspective, the Earth's orbit is a common-pool resource (Ostrom 2009, cited in Smith 2017), which must be protected amidst the increasing threat of space debris. Indonesia, together with several equatorial countries like Brazil, has special rights regarding the use of the geostationary orbit (GSO) because of their geographic conditions. This fact provides a new perspectives on the use of outer space, in the context of GSO as a natural resource (Putro *et al.* 2022). The value of international trade from the export and import of Indonesia's aerospace products is significantly rising and growing. Indonesia has a high dependency on technology (Perwitasari and Prayudya 2022). This research measures the space economy from an international economic perspective and growth theory from aerospace export and import variables. The data source was collected from international entities or organizations. The definition of aerospace and space commodities is still evolving and dependent on national missions.

Analysis: space economy trends and forecast

From the bi-bibliometric analysis above, it has been illustrated that the space economy and space industry sectors continue to develop, and that there are limitations of publication information related to the space economy concerning the space economy sector. Using a combination of ChatGPT and AI Scopus tools, current trends in space activities, forecasts, and drivers and challenges in space activities have been examined in several publications related to the space economy.

Current trends

Research summarizing the status of current trends in the space economy has been carried out using the AI Scopus and ChatGPT tools, analysis, content analysis, and data from several publications. The main results are as follows:

- New space movement: The creation of new goods and services, as well as a rise in private investment, define the new space movement. Since 2000, this movement has drawn more than $13.3 billion in investment, demonstrating the strong demand for commercial space enterprises (Christensen *et al.* 2024). This is supported by Kulu (2023). New markets, such as in-space manufacturing, commercial space stations, and orbital transfer vehicles, are emerging, indicating a shift towards a more diversified space economy.
- Constellations and small satellites: One noteworthy development is the growth of distributed satellite systems and small satellites. The development of specialized micro-launchers is a result of these technologies' growing relevance because of their flexibility and reduced production costs (Christensen *et al.* 2023; Koechel and Langer 2018). Villela *et al.* (2019) provide a statistical overview of the growth of CubeSats, i.e., small satellites that are becoming increasingly popular due to their low cost and compact size. The increase in the number of CubeSats allows more entities, including developing countries and private companies, to access space and participate in various space missions. Lagunas *et al.* (2024) highlight how Low-Earth Orbit (LEO) constellations are becoming crucial for ensuring global internet connectivity, especially in underserved regions.
- Private funding: The space industry is seeing a notable transition from public to private funding. It is anticipated that this shift will continue, with private businesses taking the lead in space exploration and exploitation (Freeman and Butler 2012).
- Commercial dominance and growth of the satellite industry: The commercial sector now accounts for a large percentage of the global space economy, accounting for 77% of total value as of 2016. This transition is mostly the result of technological and business model advances that have cut costs while expanding the client base (Christensen *et al.*2024). Previous studies by Perondi (2023) and Peeters (2021) emphasize a shift in the space industry from government-led initiatives to commercial space ventures, with the satellite sector now reaching a more mature phase and rising private investments and satellite service revenue – showing a rapid expansion in commercial space activities (Christensen *et al.* 2022). The satellite industry is moving toward large-scale commercial deployment, particularly through LEO constellations enabling global communications.
- Innovations (increased productivity and affordability): Technological advancements are making space products and services more affordable and productive, benefiting downstream markets (Christensen *et al.* 2023; 2024). Innovation in small-scale launch solutions is growing, but the business case remains uncertain. From previous studies, Boas *et al.* (2023) and

Motta *et al.* (2024) point out the rise of micro-launch vehicles as cost-effective, agile alternatives for deploying small satellites, and raise questions about the long-term market viability of such systems, given competitive pressures and economies of scale dominated by larger players.

- Government and private sector collaboration: The expansion of space activities is driven by both government initiatives and private sector investments, highlighting the collaborative nature of the space economy (Christensen *et al.* 2023; 2024)

According to the results above, the trends in the space economy with a supply chain approach, from upstream to downstream, include ground equipment stations, satellite manufacturing, launch industry, research and innovation, satellite operation, and space data services.

Table 3 shows a map of the trends in the following space economy sectors: ground equipment, satellite manufacturing, launchers, innovation, and satellite constellations. The results reflect material gathered from a large number of publications, making use of AI Scopus and ChatGPT tools.

Table 3. Trends in space economy sectors.

Sector	Key trends and insights
Space services (Christensen *et al.* 2023; 2024; Koechel and Langer 2018)	Growth in satellite telecommunications, broadcasting's and remote sensing. The industry is transitioning from high growth to a mature phase.
Ground station equipment (Dolgopolov *et al.* 2020; Freeman and Butler 2012)	Growth in network equipment, GNSS hardware, and ground stations
Satellite manufacturing (Dolgopolov *et al.* 2020; Harrison 2012)	Decline in revenues but crucial for enabling service, growth in smallsats
Launchers (Harrison 2012; Ritzenthaler and Fernandez 2019)	Development of small launchers, micro-launchers, and reliance on commercial launch services
Trends and innovations	Increased productivity, emerging markets, and government-private collaboration
Satellite constellations	LEO and smallsats dominate the global communication infrastructure

Source: Elaborated by the authors.

Each space economy sector listed in Table 3 may be broken down into its most significant components in terms of revenue. Below are the main elements and corresponding trends for each of these components.

Space services

Satellite telecommunications and broadcasting: This sector includes services such as television, radio, broadband, and mobile satellite communications. It is a significant part of the space economy, with revenues reaching $285 billion in 2023 (Christensen *et al.* 2024). The sector is evolving with the development of high-throughput communications satellites and the increasing availability of mobility connectivity services (Christensen *et al.* 2023). Aloini *et al.* (2022) stated that digital technology has transformed business models in the aerospace industry. Digital transformation enables companies to improve operational efficiency, reduce costs, and offer new services. For example, the use of data analytics and the Internet of Things (IoT) enables real-time satellite monitoring, improving decision-making and response to technical issues.

- Remote sensing: This includes Earth observation services, which are growing due to the increasing deployment of small satellites (smallsats) (Christensen *et al.* 2023; 2024). The demand for real-time, custom-tailored solutions is driving innovation in this area (Koechel and Langer 2018).

Ground equipment

- Infrastructure support: Ground equipment includes network and consumer equipment, satellite navigation service (Global Navigation Satellite System [GNSS]) hardware, and ground stations. This sector saw 4% growth in 2019, indicating its importance in the overall space economy.
- Spaceports and ground stations: These are critical for supporting the larger space services sector, enabling satellite telecommunications and remote sensing.

Satellite manufacturing

- Commercial satellites: The manufacturing of satellites, including geostationary (GEO) and LEO satellites, is a key component of the space economy. The U.S. leads in manufacturing launch vehicles, spacecraft, and satellites, although its competitive position is being challenged by other countries (Harrison 2012). The satellite manufacturing sector experienced a decline in revenues of 36% in 2019, but it remains crucial for enabling other space services (Dolgopolov *et al.* 2020).
- Smallsats and megaconstellations: The growth of smallsats and LEO megaconstellations is notable, driven by the demand for more flexible and cost-effective satellite solutions.

Launchers

- Commercial launch services: The launch industry includes medium-heavy and emerging small launch vehicles. The development of small launchers is particularly significant for deploying smallsats, providing more flexibility and reducing dependency on larger payloads (Ritzenthaler and Fernandez 2019). The U.S. commercial space industry is increasingly relied upon for human and cargo transport, as well as for launching commercial satellites (Harrison 2012). Zhang and Yang (2023) analyze the development of China's commercial space industry, legislative challenges, and regulatory solutions. China has experienced significant growth in this sector, with private companies focusing on satellite launches and space technology development. However, regulatory challenges and the need for a clear legal framework are major concerns to ensure orderly and sustainable growth.
- New space economy: The emergence of new space economy fields, such as commercial lunar activities and in-space servicing, is driving the development of novel launch capabilities (Christensen *et al.* 2021; 2023; Kulu 2023).

Several studies project the estimated market value of the space economy to grow to $ 1 trillion by 2040 (Dolgopolov *et al.* 2020). For instance, a study shows the near-future potential market for launch services (micro-launchers) (Motta *et al.* 2024) and the increasing demand for small satellite and constellation satellite launches (Christensen *et al.* 2021; 2023).

Based on several publications related to the space economy, the key drivers and challenges are summarized as follows:

- Funding: New funding sources, for example, the International Space Development Bank, are required to assist high-risk projects in the space economy (Freeman and Butler 2012). Currently, the implementation of this scheme or funding is not working. Meanwhile, the growth of space activities is driven by both government initiatives and private sector investments, emphasizing the collaborative nature of the space economy (Christensen *et al.* 2023; 2024).
- Policy and regulations: Effective policies and regulations are required to manage the increasing number of space activities. According to Koechel and Langer (2018), public policy should balance regulation and industry expansion.
- Sustainability: Maintaining a sustainable space environment is vital for the industry's growth.

To properly address sustainability challenges, businesses, regulators, and investors will need to work together (Kulu 2021). Shutler *et al.* (2022) highlight the space sector's atmospheric influence, which requires oversight. The increasing launch and satellite activities can have an influence on the Earth's atmosphere, demanding environmental laws.

- Resources: Weinzierl (2018) highlights the problems of quantifying the economic value and costs of space-related activities. Many governments and companies find it challenging to participate in the space sector due to limited resources and high expenses.

CONCLUSION

The research results show a significant increase in the number of publications related to the topic of the space economy from 2015 to 2023, indicating strong interest from the research community in the socio-economic aspects of the use of outer space. However, several publications show the existence of changes in research trends and other factors influencing the production of literature. The present research also identifies the journals that serve as the main publication venues, providing insights into

the mainstream of research and influential literature sources. Additionally, the bibliometric map provides a visualization of the relationships between concepts in the literature, highlighting clusters of research topics in the space economy, and identifying areas that still require further research, particularly related to the space industry and space sector. This research makes an important contribution to understanding the trends and dynamics in the development of the space economy. This will serve as a guide for researchers and practitioners in this field to determine the direction of future research and help build a stronger knowledge base for upcoming studies.

Another finding from the present research is that there is a major trend in space economy research towards the study of the topics "new space economy," "space sector," and "space industry" since 2020. This is demonstrated by the scarcity of publication media and the number of publications referenced in economics in general. This research theme is considered to still have a level of novelty, where the characteristics of space products and services are strategic and of dual use, having unique market characteristics, and economic structure. Several publications noted that the space economy is a new sector and that there are several studies to analyze and measure the size of the space economy.

The space economy has been mentioned as a megatrend in Indonesia's context, but there is limited research to confirm that. Space actors in Indonesia are not only the government but also private companies, universities, and others. The state or government actor is not only a regulator but also an actor in space activities together with the private sector. According to this clustering analysis above, the space industry and space sector publications and research are still limited from an economic perspective, and this is particularly true in this case. High-quality macroeconomic statistics on the importance of the space sector are very important, especially for Indonesia today. There are limited sources for analyzing the space economy in Indonesia. This presents an interesting new direction for future research in Indonesia, as space activities in Indonesia have been ongoing since the 1960s. The space economy studies in Indonesia need a multidisciplinary approach.

The space economy is expected to grow significantly due to increased private investment, technological advancements, and commercial activity. However, maintaining growth requires sensible legislation, innovative financing strategies, and a focus on sustainability. Chrysaki (2020) emphasizes the need for a voluntary code of ethics to ensure the responsible commercialization of space resources. Future studies will primarily focus on market growth, technology development, funding, and sustainability. It is expected that a shift in the space economy trend above, as shown in data and analysis from 2015-2023, will occur from traditional to new space economy, with a rising number of private and space industry indicators.

Trends in the global space economy show a rise in launchers (micro-launchers), megaconstellations in LEO orbit, growth of the global market, and business models. Value creation in the new space economy is becoming centered around satellite-based data services. This trend, according to Paravano *et al.* (2023), stresses that the real economic value in the space sector is shifting from hardware to data and downstream services, such as Earth observation, precision agriculture, and disaster response. The majority of the space economy in Indonesia is in the downstream, but there are limited resources and research to value the impact of the space industry, space sector, and space economy as a macro approach, as found in previous studies.

CONFLICT OF INTEREST

Nothing to declare.

AUTHOR CONTRIBUTIONS

Conceptualization: Perwitasari I; **Methodology:** Perwitasari I; **Validation:** Firmansyah F and Triharjanto RH; **Formal analysis:** Perwitasari I, Firmansyah F, and Triharjanto RH; **Resources:** Perwitasari I; **Writing - Original Draft:** Perwitasari I and Triharjanto RH; **Writing - Review & Editing:** Firmansyah F and Perwitasari I; **Supervision:** Triharjanto RH; **Final approval:** Perwitasari I.

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