

# Innovation and the Space Economy: Drivers, Actors, and Economic Implications

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## Abstract

The space economy is undergoing a profound transformation driven by technological advances, commercialization, and the integration of space-based capabilities into terrestrial economic activities. This study examines the role of innovation in this structural transition, focusing on its main drivers, key actors, economic implications, and policy conditions. Drawing on the OECD's conceptualization of the space economy and the literature on New Space and mission-oriented innovation, it adopts a qualitative, exploratory research design based on a structured review of academic, institutional, industry, and governmental sources, complemented by descriptive quantitative indicators. The study develops an integrated framework comprising four interconnected dimensions: technological, financial, business model, and institutional/policy innovation. It examines how interactions among these dimensions shape the development, commercialization, and diffusion of space-related innovations. The analysis suggests that technological progress alone cannot explain the transformation of the space economy; rather, it emerges from the interplay of technological advances, financing mechanisms, entrepreneurial activity, organizational arrangements, and institutional frameworks. These interactions foster hybrid public-private ecosystems involving governments, space agencies, established aerospace firms, start-ups, investors, research institutions, and downstream industries. Governments remain pivotal through public investment, procurement, regulation, infrastructure provision, and market creation. Moreover, the economic significance of space extends beyond upstream production to encompass space-enabled applications and services in communications, transportation, agriculture, finance, logistics, environmental monitoring, and security. The study also highlights the importance of policy direction, international cooperation, and effective governance in addressing challenges related to orbital congestion, cybersecurity, geopolitical competition, and unequal access to space capabilities. By integrating technological, financial, organizational, and institutional perspectives, the study advances an ecosystem-based understanding of space innovation. Its contribution lies in explaining how these dimensions interact to shape the evolution of the space economy and its capacity to generate economic

and societal value. Methodologically, it synthesizes heterogeneous indicators into a unified analytical framework, facilitating a more integrated interpretation of the drivers and implications of innovation in the space economy.

**Keywords:** Space economy, Innovation, New Space, Public-private ecosystems, Space-enabled applications

## 1. Introduction

Space activities have become an increasingly important component of the global economy, extending beyond the development and operation of space infrastructure. Their growing integration into terrestrial economic activities has contributed to the emergence of the space economy, which the OECD (2022) defines as the full range of activities and resources that create value and benefits through the exploration, understanding, management, and utilization of space. This broad conceptualization encompasses upstream activities, including research and development (R&D), manufacturing, and infrastructure provision, as well as downstream activities involving space-derived data, products, and services.

The economic significance of space stems partly from the growing dependence of terrestrial economies on space-enabled capabilities. Communications, positioning, navigation and timing, Earth observation, and satellite-based data services support activities in agriculture, transportation, finance, telecommunications, environmental monitoring, disaster management, and defense. Consequently, the economic contribution of space must be assessed not only through the production of spacecraft, launch vehicles, and related infrastructure but also through the economic and societal value generated by space-enabled applications across industries.

Innovation is central to this transformation because it enables technological capabilities to be translated into economic and societal value. As Schilirò (2024) emphasizes, innovation acts as a catalyst for progress and structural change. Advances in reusable launch systems, satellite miniaturization, artificial intelligence (AI), autonomous systems, advanced propulsion, digital communications, and cloud computing have improved space-system performance while reducing costs and barriers to access. However, innovation extends beyond technological development to encompass new financing mechanisms, business models, commercial services, organizational arrangements, and collaborative practices. These developments reshape how space capabilities are developed, financed, commercialized, and diffused.

The growing convergence between space technologies and advances originating in other sectors further reinforces this process. AI, robotics, advanced computing, and data analytics are increasingly integrated into space systems and services, while space-derived technologies and knowledge generate spillovers across terrestrial industries. These interactions create opportunities for productivity gains, market development, improved connectivity, environmental monitoring, and economic growth beyond the traditional space industry.

Innovation is also shaped by institutional and geopolitical conditions. Governments remain central actors through public investment, procurement, regulation, infrastructure provision,

and market creation, alongside private enterprises, investors, research institutions, and other participants. At the same time, space activities are influenced by national security concerns, strategic competition, and international cooperation. Their expansion raises challenges involving orbital congestion, space debris, cybersecurity, environmental sustainability, unequal access to space capabilities, and the governance of emerging commercial activities. These conditions affect the direction and pace of innovation and the distribution of its benefits.

Against this background, this study examines innovation in the space economy through an integrated analytical framework comprising four interconnected dimensions: technological, financial, business model, and institutional/policy innovation. Rather than treating these dimensions as independent drivers, the study investigates how their interactions shape the development, financing, commercialization, and diffusion of space-related innovations. It adopts a qualitative, exploratory research design based on a structured review of academic, institutional, industry, and governmental sources, complemented by descriptive quantitative indicators. Its contribution lies in integrating these four dimensions within an ecosystem-based perspective that explains how technological advances interact with financial resources, organizational arrangements, and institutional frameworks to shape the evolution of the space economy and its capacity to generate economic and societal value.

## **2. The Evolution of Space Industry**

The contemporary innovation environment in the space sector is the result of a long process of technological, institutional, and economic change. Understanding this historical development is important because the organization of space activities, the actors involved, and the mechanisms through which capabilities are developed and commercialized have changed substantially over time. The evolution from Cold War competition to today's more diverse and commercially oriented environment provides the context in which contemporary forms of space innovation have emerged.

The launch of Sputnik 1 by the Soviet Union in 1957 marked the beginning of the Space Age and initiated an intense period of competition between the United States and the Soviet Union. During the Cold War, space activities were closely associated with national security, geopolitical competition, and scientific and technological objectives. Government institutions dominated the development and financing of major space programmes, while substantial public expenditure supported military capabilities, scientific research, launch systems, satellites, and human spaceflight. As Fey and Peeters (2025) observe, the space race was closely connected to the geopolitical and national-security priorities of the Cold War. This superpower rivalry thus served not only as a strategic rationale for space endeavors, but also as a catalyst for rapid technological development.

The institutional structure established during this period was characterized by strong government leadership and large-scale public programmes. National space agencies, military organizations, research institutions, and major aerospace contractors formed the principal network through which space capabilities were developed. The high costs, technological risks, long development cycles, and strategic importance of space activities limited participation by

smaller private firms. Although private companies played important roles as contractors and suppliers, governments generally determined the objectives, financed major programmes, and controlled access to critical infrastructure and technologies.

The end of the Cold War altered these conditions. Following the dissolution of the Soviet Union, government priorities and patterns of public expenditure changed, while the commercial potential of space activities gradually received greater attention. The United States remained a leading space power, but the international space landscape became increasingly diverse as China, India, Japan, European countries, and other emerging space actors expanded their capabilities. At the same time, cooperation among governments, space agencies, universities, research institutions, and aerospace companies became increasingly important. These developments created a more diverse institutional environment in which different forms of public and private participation could emerge.

Commercialization accelerated during the 1990s and 2000s as satellite communications, Earth observation, navigation, and other space-enabled services developed into increasingly important markets. Private firms became involved not only as contractors to government programmes but also as developers and providers of commercially oriented products and services. The growth of commercial markets gradually changed incentives for investment and technological development, creating greater opportunities for firms to pursue space-related activities outside traditional government procurement structures.

This process gained further momentum during the 2000s and 2010s with the emergence of the so-called New Space paradigm. New Space is generally associated with a more market-oriented approach to space activities and with the increasing participation of start-ups, technology companies, private investors, and new commercial service providers (Punnala et al., 2025). Denis et al. (2020) identify the growth of start-ups, venture capital, small satellites, commercial launch services, and new space applications as important forces reshaping the traditional space ecosystem. Similarly, the OECD (2023) emphasizes the role of new commercial actors, financing mechanisms, and business practices in supporting innovation and expanding access to space.

The emergence of New Space was facilitated by several mutually reinforcing developments. The increasing availability of private and venture capital enabled firms to pursue higher-risk technological projects, while advances in digital technologies shortened development cycles and reduced the cost of designing and operating space systems. At the same time, growing demand for satellite communications, Earth observation, navigation, and data services created new commercial opportunities. The result was a more dynamic environment in which technological development became increasingly connected to entrepreneurial activity, private investment, and market demand.

The changing role of private firms, however, did not eliminate the importance of governments. Space activities continue to involve substantial technological risks, long investment horizons, strategic considerations, and infrastructure requirements that often exceed the capacity or incentives of individual firms. Governments remain important through research funding, procurement, regulation, standards, public-private partnerships, and the

creation of markets for emerging technologies. Mazzucato and Robinson (2018), for example, examine the evolution of NASA towards an innovation ecosystem involving public, private, and non-profit actors. Robinson and Mazzucato (2019) similarly demonstrate how NASA and the European Space Agency have increasingly employed approaches in which public institutions contribute to the creation and direction of markets for mission-oriented innovation. The contemporary structure of the space sector is therefore better understood as an increasingly interconnected system of public and private actors rather than as a simple replacement of government activity by private enterprise.

Technological developments have reinforced these institutional changes. The increasing convergence between space technologies and advances in artificial intelligence, cloud computing, big data, autonomous systems, digital communications, robotics, and other fields has expanded the range of capabilities that can be incorporated into space systems and services. According to the OECD (2025), these technological developments are contributing to new capabilities and applications in areas including Earth observation, communications, navigation, and autonomous space systems. Such convergence has also reduced development and operating costs in several areas, making space activities more accessible to a broader range of firms and institutions.

Satellite miniaturization provides a prominent example. Small satellites, including CubeSats, have reduced the cost and time required to develop and deploy certain space systems, lowering barriers to participation for universities, start-ups, and smaller firms. These developments have also supported the emergence of satellite constellations and new commercial applications (Schilirò, 2024; OECD, 2023). Improvements in launch technologies, including reusable launch systems, have similarly contributed to the expansion of commercial launch services and to reductions in the cost of accessing space. Together, these developments have strengthened the commercial viability of activities involving communications, Earth observation, navigation, and other space-enabled services.

The expansion of Earth observation illustrates how these changes have affected the relationship between space infrastructure and terrestrial economic activity. Improvements in satellite sensors, including hyperspectral imaging, together with advances in artificial intelligence and data processing, have increased the volume and usefulness of information that can be derived from space-based observations. Satellite data are increasingly applied to climate monitoring, agriculture, disaster management, infrastructure management, and natural-resource monitoring. The resulting economic value is therefore generated not only through the construction and operation of satellites but also through the data, applications, and services developed around them.

Other technological developments are expanding the range of activities that may eventually be conducted in space. Space-based manufacturing uses the microgravity environment to investigate or produce materials and products with characteristics that can be difficult to obtain under terrestrial conditions. Research conducted aboard the International Space Station, for example, has explored the production of advanced optical fibers and other materials (World Economic Forum, 2025). Developments in propulsion, robotics, autonomous systems,

and remote sensing are also expanding the potential for more complex space operations across different orbital regimes.

Research into the utilization of space resources represents another emerging area. In-situ resource utilization seeks to use materials available on the Moon, asteroids, or other celestial bodies to produce water, propellant, construction materials, and other resources. Advances in autonomous systems, spectroscopy, remote sensing, and robotics may eventually support the prospecting and processing of extraterrestrial resources. Although these activities remain at an early stage of technological and commercial development, declining launch costs and improvements in autonomous technologies are contributing to their increasing feasibility (World Economic Forum, 2025).

These developments illustrate how the historical transformation of the space industry has created new mechanisms for generating and commercializing innovation. The expansion of private participation, the emergence of new financing models, the convergence of digital and space technologies, and the growing importance of downstream applications have broadened the range of actors and activities involved in space-related innovation. At the same time, governments and public institutions continue to influence the direction of technological development through funding, procurement, regulation, and mission-oriented programmes.

The economic consequences of this transformation are reflected in expectations of continued expansion of the global space economy. Punjala et al. (2024), for example, discuss projections of a global space economy reaching approximately \$2.7 trillion by 2045, while emphasizing the diversification of activities and the increasing integration of space with terrestrial economic systems. Such projections include continued growth in established activities such as satellite communications, Earth observation, navigation, and launch services, alongside potential expansion into areas such as space manufacturing and resource utilization. These estimates should nevertheless be interpreted cautiously, as long-term projections depend on assumptions concerning technological progress, regulation, market demand, investment, infrastructure, and the commercial viability of emerging activities.

The historical evolution of the space industry has therefore established the institutional, technological, and economic conditions underlying contemporary space innovation. The transition from Cold War government programmes to a more commercially oriented and internationally diverse environment has expanded the number of actors involved, altered mechanisms of financing and commercialization, and strengthened the connection between space capabilities and terrestrial economic activity. These developments provide the historical foundation for examining innovation not simply as technological progress, but as a broader process involving firms, governments, investors, research institutions, technologies, markets, and users across the emerging space economy.

### **3. The Objectives and Methodology of the Study**

The primary objective of this study is to examine the role of innovation in the development of the space economy and its broader implications for economic activity and societal well-being on Earth. Building on the OECD's broad conceptualization of the space economy and the

literature on New Space, the study pursues four main objectives. First, it identifies the principal drivers of innovation, including technological progress, declining launch and satellite costs, digitalization, artificial intelligence, miniaturization, reusable launch systems, access to finance, market demand, and the integration of space technologies into terrestrial industries. Second, it examines the principal actors in the space innovation ecosystem, including governments and space agencies, established aerospace companies, start-ups and small and medium-sized enterprises (SMEs), universities and research institutions, investors, and downstream industries, focusing on their interactions and the emergence of hybrid public-private innovation ecosystems. Third, it assesses the economic implications of emerging space technologies and applications, including their contribution to commercial development, productivity, technological diffusion, and value creation across industries. Fourth, it investigates the policy and institutional conditions that enable or constrain innovation, with particular attention to public investment, private capital, procurement, regulation, public-private partnerships, international cooperation, and market creation.

The policy dimension draws on the literature on mission-oriented innovation, which emphasizes the role of public institutions in shaping markets and coordinating innovation around major societal challenges (Mazzucato, 2018; Robinson & Mazzucato, 2019; Hekkert et al., 2020; Uyarra et al., 2025). Wanzenböck et al. (2020) conceptualize mission-oriented innovation policy as a directional approach that begins with a societal problem and establishes a goal-oriented strategy to address it. This perspective highlights the importance of directionality in innovation policy, extending the analysis beyond the rate and propensity of innovation to consider the objectives, mechanisms, and rationales of public intervention.

To address these objectives, the study adopts a qualitative, exploratory research design based primarily on a structured literature review, complemented by conceptual analysis and descriptive quantitative indicators. The review is structured around four interconnected dimensions of innovation in the space economy: technological innovation; financial and investment innovation; business model and organizational innovation; and institutional and policy innovation. These dimensions provide the analytical basis for examining how technological capabilities interact with financing mechanisms, market structures, organizational arrangements, institutional frameworks, and user demand. An ecosystem perspective is therefore central to understanding the evolving relationships among public authorities, established aerospace companies, entrepreneurial firms, investors, research institutions, and downstream industries (Schilirò, 2024; Denis et al., 2020; Mazzucato & Robinson, 2018).

The four analytical dimensions complement the study's four research objectives. Whereas the objectives identify the principal questions concerning innovation drivers, ecosystem actors, economic implications, and policy conditions, the dimensions provide a framework for analyzing the mechanisms through which these factors interact. This distinction enables the study to move beyond a descriptive account of technological developments and market trends towards an integrated interpretation of the processes shaping the transformation of the space economy.

The literature search focused on the development of the space economy, the emergence of New Space, the commercialization and diffusion of space technologies, innovation ecosystems, and the interactions between space-related innovation and terrestrial economic activities. This broad economic perspective is consistent with Punjala et al. (2024), who emphasize the growing importance of the space economy and its expanding connections with the wider economy.

The search strategy combined academic database searches with targeted searches of institutional, governmental, and industry publications. Scopus served as the principal academic database, supplemented by Google Scholar to identify additional relevant studies and trace references cited in key publications. Institutional sources included reports and policy documents published by the OECD, the European Space Agency (ESA), the European Commission, the World Economic Forum, and relevant national space agencies. Industry and market reports were consulted selectively to provide supplementary evidence on market developments, investment trends, emerging technologies, and commercial applications.

Search terms were combined using Boolean operators (AND and OR), with search strings adapted to the requirements of individual databases and institutional sources. Core search terms included space economy, New Space, space innovation, space commercialization, space entrepreneurship, space technology, innovation ecosystem, satellite applications, space investment, venture capital, business models, public-private partnerships, mission-oriented innovation policy, and space governance. The review covered literature published between 2010 and 2026. Earlier publications were included when they offered foundational theoretical contributions to innovation, technological diffusion, economic development, innovation ecosystems, or mission-oriented innovation policy.

Source selection followed four principal criteria. First, thematic relevance required a substantive contribution to at least one of the four analytical dimensions or to the relationship between space innovation and the wider economy. Second, source credibility gave priority to peer-reviewed academic publications, established scholarly books, and reports from recognized institutional and governmental organizations. Third, analytical and empirical contribution concerned the relevance of theoretical frameworks, empirical findings, policy analyses, investment data, market estimates, and documented technological developments. Fourth, temporal relevance was particularly important for evidence concerning recent market developments, investment flows, commercial applications, and regulatory changes. Industry reports were included selectively, with attention to their definitions, data sources, potential commercial interests, and forecasting assumptions.

Sources were excluded when they lacked a clear connection to the research objectives, offered no identifiable analytical or evidential contribution, duplicated information available from more authoritative sources, or relied on market estimates whose definitions and assumptions could not be adequately assessed. The selected literature was synthesized thematically across the four analytical dimensions, with particular emphasis on the interactions among technological development, financing, commercialization, organizational change, and public policy. The purpose was to develop an integrated analytical account of the

processes shaping innovation in the space economy rather than to produce a statistically exhaustive inventory of publications.

Descriptive quantitative indicators complement the qualitative synthesis by contextualizing economic developments, investment patterns, and market trends. These indicators measure different aspects of the space economy and cannot necessarily be combined into a single aggregate measure. Moreover, substantial variation in long-term market forecasts reflects differences in definitions, methodologies, and underlying assumptions. Projections are therefore interpreted as indications of potential market scale and direction rather than as precise predictions. This approach recognizes the measurement challenges associated with the space economy, whose boundaries extend beyond conventional industrial classifications and whose economic effects frequently arise indirectly through space-enabled products and services. Accordingly, the methodological contribution lies in the structured interpretation of heterogeneous indicators within a common analytical framework, rather than in the development of a new measurement methodology.

Overall, the methodology integrates literature-based analysis, conceptual interpretation, and descriptive economic evidence to examine the space economy as a dynamic innovation ecosystem. By linking technological developments with financial and investment mechanisms, business models and organizational arrangements, and institutional and policy conditions, the study provides an integrated framework for understanding how innovation transforms the space sector and how the resulting technologies, services, and business models contribute to economic development and the resolution of broader societal challenges on Earth.

#### **4. Literature Review**

The literature identifies innovation as a central driver of the transformation of the space economy, emphasizing that its development extends beyond technological progress alone. Advances in launch systems, satellite technologies, digitalization, artificial intelligence (AI), miniaturization, and data processing have lowered barriers to entry and created new commercial opportunities. Simultaneously, changes in financing, business models, organizational arrangements, and public policy have reshaped relationships among governments, established aerospace companies, start-ups, investors, research institutions, and downstream users. The space economy can therefore be understood as an evolving system in which technological, financial, organizational, market, and institutional factors interact.

Technological progress has expanded the possibilities for space exploration and commercial applications. Advances in propulsion, robotics, AI, satellite technology, and onboard computing have improved operational capabilities and contributed to cost reductions. Reusable launch vehicles, small satellites, advanced communication systems, and enhanced data processing have further created opportunities for commercial and research activities.

The OECD (2016) establishes an important foundation for understanding the economic significance of space innovation. Its analysis emphasizes that innovation extends beyond spacecraft, launch systems, and other hardware to encompass the development and diffusion

of technologies, services, data, and applications that support innovation in other sectors. Research and development (R&D), technological spillovers, commercialization, and the application of space-derived technologies to terrestrial activities are therefore central to assessing the economic contribution of space.

This perspective is consistent with the wider innovation literature. Schumpeter (1934) identified innovation as a principal driver of economic development, while Kline and Rosenberg (1986) and Fagerberg (2013) emphasized its cumulative and interactive nature, involving technological, organizational, and institutional change. Innovation is consequently better understood as a process than as a discrete technological event. This interpretation is particularly relevant to the space sector, where technological risks, substantial capital requirements, and long development cycles make sustained investment and supportive institutional conditions essential (Summerer, 2012).

The economic effects of innovation also depend on adoption and diffusion. Rogers (2003) identifies innovation, communication channels, time, and the social system as fundamental elements of diffusion. In the space economy, technological advances generate broader economic benefits when integrated into terrestrial markets and production systems. Satellite communications, navigation technologies, Earth-observation services, and space-derived data support applications in transportation, agriculture, logistics, telecommunications, and environmental monitoring (OECD, 2016). The integration of satellite systems with terrestrial networks, including 5G and emerging non-terrestrial networks, further creates opportunities for data processing, analytics, and commercial services (OECD, 2023).

These developments complicate the definition and measurement of the space economy. The OECD (2022) distinguishes between upstream activities, including R&D, manufacturing, and launch; downstream activities, which directly depend on space infrastructure, data, and signals; and space-derived activities, through which space-related capabilities generate value in wider economic activities. Undseth and Jolly (2026) similarly emphasize the difficulties of measuring an increasingly interconnected space economy and improving comparability across countries and activities. These contributions highlight the need to distinguish economic activity within the space sector from the wider value generated by space-enabled applications.

The transformation of the space sector is increasingly associated with the emergence of the New Space economy. D'Costa (2026) characterizes New Space in terms of commercialization, greater private-sector participation, entrepreneurship, and changing forms of public-sector engagement. Peeters (2021) similarly describes a transition from predominantly government-funded activities toward greater commercial participation and private financing, particularly since around 2000. Declining launch costs and the development of low-cost small satellites have further lowered barriers to entry and enabled new commercial and research activities (Delmaire & Malisuwan, 2025; Schilirò, 2024; OECD, 2023).

The expansion of New Space has increased the importance of relationships among multiple actors. Granstrand and Holgersson (2020) define innovation ecosystems as evolving

constellations of actors, activities, institutions, and relationships that influence innovative performance. This perspective is relevant to a sector involving governments, space agencies, established aerospace firms, start-ups, universities, investors, suppliers, and downstream users. Cavallo, Messeni Petruzzelli, and van de Vrande (2026) apply this approach to space entrepreneurship, emphasizing how interactions and complementary capabilities create entrepreneurial opportunities. Dedehayir, Mäkinen, and Ortt (2022) highlight connections, trust, complementarities, and value-creation mechanisms within innovation ecosystems, while Davies et al. (2023) emphasize R&D, investment, and technological infrastructure.

These relationships combine collaboration and competition. Firms depend on complementary technologies, knowledge, infrastructure, financing, and networks while competing to develop products, services, and markets (Schilirò, 2024). New Space therefore involves not simply a shift toward private-sector activity but also a transformation in the composition of innovation ecosystems and in the relationships through which technologies are developed and commercialized.

Financing is another important dimension of the New Space transformation. Historically, space capabilities depended heavily on government funding because of substantial capital requirements, technological risks, and long development cycles. New Space has increased the role of private equity, venture capital, corporate investment, and other forms of private finance (Peeters, 2021; D’Costa, 2026). Access to finance influences the pace and direction of innovation by enabling firms to develop technologies, build organizational capabilities, and enter emerging markets.

However, the growing importance of private capital does not imply the replacement of public funding. Government investment, procurement, infrastructure, and research programmes can support technological development and reduce commercial uncertainty, while private capital facilitates commercialization and scaling. Public and private resources therefore perform complementary functions within the space innovation ecosystem. Understanding New Space requires examining not only the availability of financial resources but also their interaction with technological risks, market opportunities, and institutional arrangements.

Technological capabilities must be translated into economically viable products and services. Business-model and organizational innovation are consequently important complements to technological development. Firms increasingly extend their activities beyond space hardware toward services, data, connectivity, analytics, and integrated solutions.

Logiudice, Panniello, and Messeni Petruzzelli (2026) examine how firms from terrestrial industries can adapt their business models to exploit opportunities created by the space economy, emphasizing value creation and value capture. Fiore and Elvis (2026) similarly highlight the interaction between technological and business innovation in New Space. They argue that market-oriented approaches, competition, vertical integration, production at scale, and service-oriented business models can reduce mission costs and development times. Iterative development and greater openness to experimentation can further support innovation, while new commercial arrangements can enable scientific activity and public value creation.

These contributions suggest that technological advances do not automatically translate into economic value. Their effects depend partly on the organizational capabilities, commercial strategies, and business models through which innovations reach users. Business-model innovation also connects technological development with financing by shaping revenue generation, investment incentives, market access, and the scalability of commercial activities.

Public institutions remain central to the transformation of the space economy. New Space does not necessarily imply state withdrawal; rather, it involves changing relationships between public and private actors. Del Monte and Aliberti (2026) emphasize that public institutions continue to shape commercialization as enablers, partners, and customers. Castelnovo et al. (2026) identify public procurement as a mechanism connecting public and private actors. By specifying performance requirements while allowing firms to develop and operate technological solutions, space agencies can stimulate innovation, support suppliers, reduce market uncertainty, and create demand for emerging technologies.

This perspective is consistent with the literature on mission-oriented innovation policy. Mazzucato (2018) and Robinson and Mazzucato (2019) emphasize the capacity of public institutions to shape markets and coordinate innovation around societal challenges. Hekkert et al. (2020) and Wanzenböck et al. (2020) similarly highlight directionality, coordination, and goal-oriented strategies. This approach extends innovation policy beyond the pace of technological change to encompass its direction, purpose, and societal objectives.

In the space economy, public policy influences resource allocation, market development, and the coordination of public and private capabilities. International cooperation and regulatory frameworks are also important in addressing orbital congestion, space debris, cybersecurity, environmental sustainability, unequal access, and geopolitical competition. These challenges demonstrate that innovation depends not only on technological capabilities and market incentives but also on institutional arrangements and governance mechanisms.

Taken together, the literature establishes that innovation in the space economy is a multidimensional, ecosystem-based process. However, the contributions discussed above generally approach its development through complementary analytical perspectives. The OECD (2016, 2022, 2023), for example, examines the economic significance of space activities, the diffusion of space-derived technologies, and the challenges of defining and measuring an increasingly interconnected space economy. Recent chapters in the *Oxford Handbook* address specific aspects of New Space, including entrepreneurship, innovation ecosystems, business-model adaptation, commercialization, financing, and the evolving role of public institutions. These contributions provide important foundations for understanding the sector while highlighting the value of examining the relationships among innovation dimensions within a common analytical framework.

Building on this literature, the present study develops an integrated framework comprising four interconnected dimensions: technological innovation; financial and investment innovation; business-model and organizational innovation; and institutional and policy innovation. Its contribution lies not in identifying these dimensions individually, but in examining their interactions and complementary roles in shaping the space economy.

Technological advances can create investment opportunities; financing can support technological development and commercialization; business models and organizational capabilities can facilitate adoption and diffusion; and institutional arrangements and public policy can influence resource allocation, market development, and the direction of technological change.

This framework connects innovation within the space sector to the wider economic effects of space-enabled applications while incorporating the financial, organizational, and institutional conditions that shape these processes. It provides the conceptual foundation for four research objectives: identifying the principal drivers of innovation; examining the actors and relationships within the innovation ecosystem; assessing the economic significance of emerging technologies and applications; and analyzing the institutional and policy conditions that facilitate or constrain innovation. It also informs the descriptive quantitative analysis, which draws on indicators of market size, investment, technological deployment, launch activity, and downstream markets to contextualize the qualitative evidence and identify broader structural trends in the development of the space economy.

## **5. Descriptive Quantitative Indicators**

Descriptive quantitative indicators are used to provide empirical context for the qualitative analysis and to illustrate the scale, evolution, and economic significance of the space economy. Their purpose is not to estimate an econometric model or establish causal relationships, but to identify broad patterns and structural trends in market development, public and private investment, technological deployment, entrepreneurship, and downstream activity. They therefore complement the literature-based analysis by documenting the expansion of the space economy and its growing integration with the wider economy.

As discussed in Section 3, the boundaries of the space economy extend beyond activities conventionally classified as part of the space industry. The OECD (2022) distinguishes between upstream activities, including R&D, manufacturing, and launch services; downstream activities, which directly depend on space infrastructure, data, and signals; and space-derived activities, through which space-based capabilities generate value in activities that are not themselves directly dependent on space systems. This distinction is essential when interpreting quantitative indicators, since available estimates cover different segments of the space economy and are not necessarily directly comparable.

Market-size estimates provide an initial indication of the scale of economic activity associated with space. Space Foundation (2025) estimates that the global space economy reached approximately \$613 billion in 2024, representing year-on-year growth of 7.8%. Commercial revenues accounted for 78% of the total, while government spending represented the remaining 22%. Government space spending amounted to approximately \$132 billion, including \$77 billion allocated by the United States to national security and civil space programmes. These figures illustrate the substantial scale of the space economy and the continuing importance of public expenditure alongside commercial activity.

A broader forward-looking estimate is provided by the World Economic Forum and

McKinsey & Company (2024), which project that the global space economy could reach approximately \$1.8 trillion by 2035, compared with around \$630 billion in 2023. This projection implies average annual growth of approximately 9%. It reflects the increasing integration of space-enabled technologies—including communications, positioning, navigation and timing, and Earth observation—into a wider range of economic activities. Unlike estimates focused primarily on revenues generated within the space sector, this projection also incorporates the value created by space-enabled applications across other industries.

These estimates should not be interpreted as directly comparable measures of the same economic aggregate. Space Foundation's estimate concerns the current size of the space economy, based on commercial revenues and government spending, whereas the World Economic Forum and McKinsey projection adopts a broader perspective that incorporates the economic value associated with space-enabled applications. The figures are therefore best understood as complementary indications of the sector's scale and potential development rather than as precise measures of a single, clearly bounded industry.

The expansion of the space economy is expected to depend increasingly on the diffusion of space-enabled capabilities across the wider economy. Communications, positioning, navigation and timing, and Earth observation can generate value in sectors such as transportation and logistics, agriculture, defence, retail, consumer goods, and digital communications. This development highlights a central finding of the literature: the economic significance of space increasingly depends on the integration of space-based infrastructure, data, and services into terrestrial economic activities.

ESA (2026) provides a more narrowly defined indicator, estimating the global downstream space market at approximately €490 billion in 2025, with Europe accounting for approximately 19% of global downstream market demand. This estimate should be considered separately from the broader Space Foundation and World Economic Forum-McKinsey figures because it focuses specifically on downstream activities, including satellite communications, Earth observation, and markets associated with the Global Navigation Satellite System (GNSS). It further illustrates the importance of distinguishing between segments of the space economy when interpreting market estimates.

Taken together, these indicators suggest that the economic significance of space lies not only in the sector's overall size but also in the growing importance of commercial activities and the diffusion of space-enabled capabilities into other industries.

A second group of indicators concerns the financial resources devoted to space activities. Public expenditure remains essential because governments support research, infrastructure, national space capabilities, procurement, and strategic programmes. Public spending consequently provides an important indicator of the continuing role of governments in the space innovation ecosystem.

Figure 1 presents global public investment in space from 2021 to 2026.

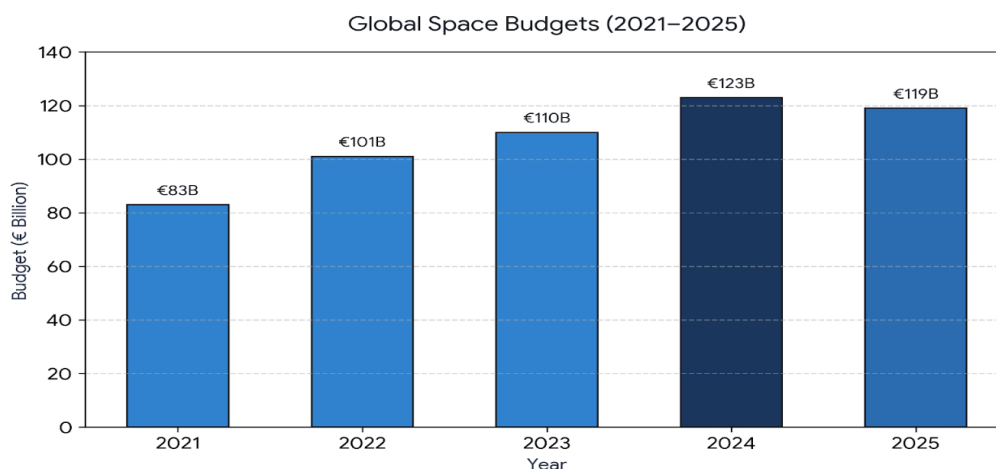


Figure 1

Source: ESA (2026)

According to ESA (2026), global public investment in space, including civil and defence programmes, reached approximately €123 billion in 2024 before declining to €119 billion in 2025. The 2024 figure represented an increase of approximately 9% compared with 2023, while defence expenditure accounted for approximately 54% of institutional space budgets. These figures highlight the strategic and geopolitical importance of space and the substantial role of public expenditure in maintaining and developing space capabilities.

The decline in public investment to €119 billion in 2025 should not necessarily be interpreted as evidence of a contraction in the space economy. ESA attributes the decrease primarily to changes in United States defence expenditure and broadly stable NASA funding. The movement is therefore more appropriately understood in terms of changes in the scale and composition of public spending than as evidence of a general weakening of space activity.

Meanwhile, global private investment in space ventures reached approximately €11.7 billion in 2025, an increase of 60% compared with 2024 (ESA, 2026). The coexistence of substantial public expenditure and growing private investment illustrates the hybrid character of the contemporary space economy. Governments continue to support the sector through funding, procurement, infrastructure, and institutional programmes, while private capital contributes to commercialization, technological development, and entrepreneurial activity. These sources of finance are complementary but not equivalent: they may serve different purposes and operate according to different investment horizons, risk tolerances, and strategic priorities.

Venture capital provides a more specific indicator of entrepreneurial finance and private-sector expectations concerning emerging space markets. Investment flows can signal expectations about future demand, technological feasibility, and the potential scalability of business models, although they do not establish that these expectations will be realized.

BryceTech (2026) reports that investment in space start-ups amounted to \$10.9 billion in 2025, with 208 companies receiving investment across 235 deals. United States start-ups accounted for \$7.3 billion, or approximately two-thirds of global start-up investment. Venture capital represented 79% of start-up funding, while 397 first-time investors participated in the sector. Initial public offering (IPO) financing amounted to \$1.3 billion across four deals. These figures illustrate the scale of entrepreneurial finance and the concentration of investment in United States companies.

The BryceTech figures should be distinguished from ESA's broader estimate of €11.7 billion in global private investment in space ventures. The two measures are not directly interchangeable because they differ in scope and definition: BryceTech focuses specifically on start-up investment, whereas ESA considers private investment in space ventures more broadly. The concentration of investment in United States companies also suggests that access to private capital remains geographically uneven. Venture capital therefore provides evidence of perceived technological opportunities and entrepreneurial dynamism, while also revealing differences in the financial ecosystems available to space companies across countries and regions. Nevertheless, high investment levels do not necessarily translate into technological success, commercial viability, or long-term economic value. Venture capital indicators should therefore be interpreted as measures of financing activity and investor expectations rather than as direct measures of innovation outcomes.

Launch activity provides a further indicator of technological deployment and industrial activity. ESA (2026) reports 324 orbital launch attempts in 2025, of which 315 were successful, and estimates the global upstream market at approximately €75 billion. The upstream market, which includes spacecraft manufacturing and launch-service provision, remained strongly dependent on institutional demand, with institutional customers accounting for approximately 80% of its value.

The increase in orbital launch attempts from 259 in 2024 to 324 in 2025 represents growth of approximately 25%. This expansion is consistent with the deployment of satellite constellations, rising demand for space-based services, and continued investment in space infrastructure. However, launch frequency should not be treated as a direct measure of innovation. An increase in launches indicates greater deployment and industrial activity but does not necessarily imply a proportional increase in technological productivity, economic value, or societal benefits. Launch statistics are therefore most informative when interpreted alongside investment trends, market estimates, and indicators of downstream activity.

The contribution of space-enabled applications to economic activities beyond the traditional space sector warrants particular attention. A substantial share of the economic value associated with space arises from the use of satellite data, signals, communications, and services throughout the wider economy. ESA (2026) estimates the global downstream market at approximately €490 billion in 2025, with GNSS services accounting for approximately 77% of downstream demand and Europe representing approximately 19% of the global market. These estimates underline the economic scale of activities extending beyond upstream manufacturing and launch services.

Space-enabled capabilities support a wide range of terrestrial sectors, including transportation and logistics, agriculture, financial services, telecommunications, environmental monitoring, and defence. Their economic significance consequently depends not only on the production and operation of space infrastructure but also on the extent to which this infrastructure is integrated into broader economic systems.

Assessing these wider contributions requires methodological caution. The value generated by space-enabled applications is often difficult to attribute exclusively to space infrastructure because space-derived inputs are combined with terrestrial technologies, data, labour, and capital. Revenues generated by space companies therefore capture only part of the economic value associated with space capabilities. Wider effects may arise through productivity improvements, better information, new services, improved decision-making, and technological diffusion. However, these effects are difficult to isolate and quantify because they emerge from interactions among space technologies and other technological, institutional, and market factors. The indicators presented here should therefore be interpreted as evidence of the scale and orientation of space-enabled activity, rather than as exhaustive measures of total economic impact.

Overall, these quantitative indicators offer complementary perspectives on the scale and evolution of the space economy. Market estimates indicate the sector's current size and projected growth; public and private investment figures reveal the resources mobilized to support its development; venture capital data highlight entrepreneurial financing and its geographical concentration; launch statistics track technological deployment; and downstream indicators illustrate the integration of space-enabled capabilities into the wider economy. No single indicator captures this multifaceted process, and differences in definitions and coverage limit direct comparisons across data sources. The quantitative evidence is therefore best treated as a set of complementary indicators of structural change, rather than as a unified measure of a single economic aggregate. Combined with the qualitative analysis, these indicators support the study's integrated framework by contextualizing technological developments, financial mechanisms, organizational change, and institutional influences in the evolution of the space economy.

## **6. Conclusion**

This study examined the role of innovation in the development of the space economy and its broader economic and societal implications. As Schilirò (2024) emphasizes, innovation is a catalyst for progress and change. The analysis indicates that the transformation of the space economy cannot be explained by technological advances alone; rather, it results from the interaction of technological progress, investment, entrepreneurship, organizational change, public policy, and the diffusion of space-enabled capabilities across the wider economy.

Core technological breakthroughs such as reusable launch systems, satellite miniaturization, artificial intelligence, advanced communications, and improved data processing have reduced costs, enhanced operational capabilities, and created new commercial opportunities. However, the emergence of the “New Space” paradigm reflects a broader transformation in which private firms, investors, research institutions, and downstream users play increasingly

important roles alongside governments and established aerospace companies. This evolution does not diminish the importance of the public sector, which remains central through investment, research, infrastructure provision, procurement, regulation, and market creation. The contemporary space economy is therefore best understood as a hybrid public-private ecosystem in which diverse actors contribute complementary resources, knowledge, and capabilities.

The economic significance of space extends far beyond hardware manufacturing, satellite deployment, and launch infrastructure. Space-enabled services increasingly support communications, transportation, agriculture, logistics, environmental monitoring, finance, and defence. Their broader economic contribution depends on the adoption and diffusion of space-based technologies across terrestrial activities. While descriptive indicators—such as market size projections, public expenditure, venture capital inflows, and downstream usage—corroborate the ongoing commercialization and integration of space activities, analytical challenges remain. Discrepancies in measurement methodologies, geographical scope, and data definitions impede direct cross-study comparability. Furthermore, isolating the unique value added by space assets from complementary terrestrial infrastructure poses a persistent empirical hurdle. Accordingly, available indicators should be interpreted as evidence of structural trends rather than as precise estimates of the space economy's aggregate economic contribution.

The analysis also highlights the importance of public policy and effective governance in shaping the direction and outcomes of space innovation. Public investment, procurement, regulation, public-private partnerships, and international cooperation influence technological development and market formation, while supporting societal objectives such as connectivity, climate and environmental monitoring, disaster management, and security. At the same time, the expansion of space activities intensifies challenges related to orbital congestion, space debris, cybersecurity, environmental sustainability, unequal access to space capabilities, and geopolitical competition. Effective governance must consequently reconcile commercial development and technological progress with security, sustainability, and the equitable distribution of benefits.

The study's principal conceptual contribution is an integrated, ecosystem-based framework that conceptualizes space innovation through four interconnected dimensions: technological innovation; financial and investment innovation; business model and organizational innovation; and institutional and policy innovation. Rather than treating these dimensions as independent drivers, the framework emphasizes their interdependence in shaping the development, financing, commercialization, adoption, and diffusion of space technologies. This perspective connects innovation processes with economic value creation, explaining how interactions among technological capabilities, financial resources, organizational arrangements, and institutional conditions can extend the benefits of innovation beyond the boundaries of the space sector. Methodologically, the study complements this conceptual approach by interpreting heterogeneous descriptive indicators within a common analytical framework, while acknowledging the limitations of cross-source comparability and aggregate measurement.

Looking ahead, the development of the space economy will depend not only on continued technological progress but also on the financial, organizational, and institutional conditions that enable innovation to be commercialized, governed, and widely diffused. The central challenge for policymakers and market actors is to align technological and commercial opportunities with effective governance and long-term societal objectives. Ultimately, the performance of the space economy should be assessed not only in terms of market expansion and commercial returns but also in terms of its contribution to sustainable economic development and the resolution of broader societal challenges on Earth.

**Competing interests**

Not applicable.

**Informed consent**

Obtained.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

**Data sharing statement**

No additional data are available.

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