SPACE EXPLORATION'S IMPACT ON ECONOMIC GROWTH[1]

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ABSTRACT

Space research can have a profound effect on Earth's challenges, provide solutions in a variety of industries, and promote economic growth and development. The space economy is concerned with the use of resources and the implementation of actions (during the exploration, understanding, and use of space) that provide value and advantages for humans. The space economy generates half a billion dollars in global income, and it is expected to grow dramatically in the coming years. One of the primary reasons for this optimism is that space technology, such as satellites, are being employed to support internet infrastructure. Space technology enables global positioning systems (GPS) (which makes traditional maps obsolete), mobile banking, weather forecasting (which assists farmers in adequately preparing for potential weather problems), broadcasting television programs, maintenance video conferencing, and device interconnection. Above all, space exploration can boost GDP and create new jobs. The data gathered by researchers via multiple space missions about human survival in extremely severe environments (how to grow food or survive with very limited natural resources, for example) gave solutions to many problems on Earth. Countries battling drought and food shortages can now experiment with new space technologies. Acknowledging the potential of space technology, numerous businesses, including pharmaceutical companies, are testing their products in the International Space Station's microgravity. The creation of inventions that can directly support sustainable development is another growing application for these technologies. These innovations can lessen the consequences of climate change or enhance the handling of natural disasters on a worldwide scale. Less developed nations will be able to participate in space research, which will directly boost their economies, as a result of the state and private sectors working together in this field and ultimately reducing costs associated with space exploration.

Keywords: Space exploration, Space economy, Space technology, Economic growth

INTRODUCTION

Numerous studies indicate that space-related activities can have a major economic impact on many industries, although the revenue multiplier effect frequently occurs only after years of research and development have produced functional space systems. Of course,

[1] The paper presents findings of a study developed as a part of the research project “Serbia and challenges in international relations in 2024”, financed by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, and conducted by Institute of International Politics and Economics, Belgrade during year 2024.

because of the creation of products that are limited to internal use or space industry-supporting programs, a significant amount of capital still exists in the sector (Bach et al., 2002).

The space economy is not limited to research and technology. Because of its many good benefits, the global space industry is promoting sustainable development and stimulating the economy (Klecha & Co., 2022). Companies that consider their environment and the demands of the local community in which they deliver services have a strategic advantage over competitors (Baltezarević & Baltezarević, 2020). In the coming years, space-related undertakings will have the biggest influence on terrestrial operations due to their ability to stimulate innovation. They create new markets and industrial capacities, provide job opportunities, and mostly rely on academic research and development (Klecha & Co., 2022).

The increasing commercialization of space exploration is the new space economy. Space exploration is funded in part by start-ups, businesses, and private investors. The contemporary space exploration, commonly called NewSpace, differs from previous space exploration in that the government is not required to become involved in every way (Piloto, 2023). In today's highly competitive global economy, innovation is becoming increasingly important for company success (Baltezarević & Baltezarević, 2017). The space industry is the most promising to emerge since the beginning of the technology sector, and development is expected to soar in the years to come thanks to the efforts of established players like Northrop Grumman and Boeing as well as more recent entries like Virgin Galactic, SpaceX, and Blue Origin. Economists from the US Chamber of Commerce predict that by 2040, the industry would be valued at least $1.5 trillion. Even while it's impossible to predict exactly how our economy will develop in 20 years, one thing is for sure: the private space industry will revolutionize how people live, interact, and conduct business around the world (Clark, 2020).

THE ROLE OF THE SPACE ECONOMY IN ADVANCING ECONOMIC DEVELOPMENT

Space exploration comes at a time of rising global income and wealth disparity as well as unprecedented disruption from climate change, despite the fact that it has the potential to spur future economic growth and scientific advancement (Weinzierl, 2023). The term "space economy" refers to the entire spectrum of endeavors and resource use that add value and help humans during the course of space exploration, study, comprehension, management, and utilization (OECD, 2014). It is commonly known that public funding for space exploration has significant economic benefits. For example, NASA's first economic impact report, published in 2020, revealed that the agency supported over 300,000 jobs nationwide, produced over $64 billion in total economic output during fiscal year 2019, and generated an estimated $7 billion in federal, state, and local taxes across the country (Inclán et al., 2020).

The space economy generated 469.3 billion dollars in revenue globally in 2021, while commercial space products and services brought in 224.2 billion dollars (Statista, 2023). These numbers are expected to increase to more than 50% by 2040 as satellite and other space-based technologies are used for internet infrastructure (Placek, 2023). There are currently three main categories that dominate the space market. In 2018, the market as a whole brought in USD 360 billion. Of this total, USD 125 billion might be attributed to ground-based technology such as satellite TV or broadband receivers or satellite navigation systems. The largest aerospace-based commercial service, worth USD 102 billion, is the

transmission of television, radio, or broadband signals. Other services currently have a far smaller function (Bardt, 2019).

It is crucial to keep in mind that historically, military goals have been linked to budgetary investments in space exploration. One example of this is the Cold War, which prioritized geopolitical and military goals over economic ones (Bowen, 2022). Innovative technologies including as robotics, quality control procedures, big data-driven approaches, virtual testing, and robotics testing can help space industries achieve significant manufacturing advancements. With regard to design freedom, streamlined production stages, lower costs, and improved performance, advanced manufacturing, which includes surface engineering, composite manufacturing, virtual manufacturing, embedded sensors, process modeling, and simulation may create new avenues for industrial growth (Coykendall et al., 2023).

Beyond the immediate industrial benefits, such as GDP impacts and job effects, funding space operations and the construction of space infrastructure also stimulates broader societal and economic benefits. The development of varied non-space industrial sectors is facilitated by the capacity building that a country needs to construct space infrastructure, such as in manufacturing and electronics, in order to meet the demands of the space supply chain. In order to meet the innovation requirements of the new space trends, national industries should be stimulated (PwC, 2020). This will ensure the growth and retention of highly skilled labor, as well as the advancement of domestic technology development and R&D activities. Additionally, stimulating national industries will generate spillovers in various sectors, ensuring nationwide industrial competitiveness (Ibid). These days, space-based technology is essential to our everyday existence. Take, for instance: a) Global positioning systems (GPS) are made possible by satellites, rendering physical maps mostly obsolete. GPS technology powers everything from self-driving cars to Uber trips. b) Almost all financial transactions, including credit card swipes and mobile banking apps, are made possible by satellites. c) Satellites make it possible to predict the weather more precisely, informing people when to expect rain and enabling towns to prepare roads for a snowstorm in advance. d) The transparency of nation-states' actions is being enhanced by satellite data. Satellites can provide real-time insight on the progress of events. e) The $65 billion satellite communications market supports a wide range of everyday activities, from emissions tracking and videoconferencing to agriculture and the interconnectivity of the Internet of Things (IoT) (Verified Market Research, 2021).

For geopolitical and financial reasons, nations with space programs are investing more in down-to-earth space applications (such as telecommunications and earth observation). Despite this, global space agencies and business continue to prioritize science and space exploration as primary drivers of investment (OECD, 2011). By providing internet connectivity rural areas, satellite connectivity may benefit public health and education. For example, the newly launched Bangabandhu-1 communications satellite from Bangladesh transmits radio and television programs as well as providing internet, telemedicine, and distance learning services for those living in remote areas (Piloto, 2023).

A number of long-term and enduring challenges facing the 21st century, including the environment, the use of natural resources, the management of natural disasters, international mobility, and the shift to a knowledge society, may benefit greatly from space applications due to their special qualities (OECD, 2005). Private businesses, in contrast to the public sector, frequently give priority to research projects that yield short-term financial returns. These discoveries might be kept under wraps, especially if they are thought to provide competitive benefits (Grinols & Lin, 2011). New Space companies receive funding from

multiple sources. Elon Musk, Jeff Bezos, Richard Branson, Paul Allen, and other well-known businessmen have launched companies based on innovative approaches to technology and space access management by using their riches to get past high fixed-cost barriers to entry (Weinzierl, 2018). Public-Private Research and Development Partnerships (PPRDPs) serve as an efficient means of connecting the private sector to public sources of funding and intellectual resources. They are partnerships involving the government, private sector, and research universities. To increase their influence, they might also coordinate intellectual property rights and private innovation initiatives (Rausser et al., 2023).

The space sector's intense research also produces a unique knowledge basis for its industrial activity that sets it apart from other sectors that were cooperatively created in earlier phases, such the aviation sector. The space industry is found to be primarily analytical, whereas the aviation industry is primarily synthetic, based on the categorization of industries according to their degree of embeddedness into knowledge bases, which allows them to be described as synthetic (engineering-based), analytical (science-based), or symbolic (artistic-based) (Boschma, 2018). The benefits that the public receives from space exploration are greatly enhanced by the growing involvement of the commercial sector. SpaceX's reusable rockets are an example of how private innovation and public-private partnerships may work together to reduce the cost and increase accessibility to space travel. The fact that businesses are more willing to assume more risk than government space organizations allow for the faster completion of these objectives (Weinzierl & Sarang, 2021). Earthly issues are directly impacted by space science. The world can benefit from the discoveries made by humanity when we rise to the challenges of space exploration. By learning how to cultivate food in harsh environments on Earth, we may be able to lessen the effects of climate change. This includes researching potential agricultural practices on Mars. By advancing our understanding of the human body, medical research conducted aboard the International Space Station enhances everyone's quality of life (Planetary, 2023).

There is commercial potential for many space-based activities, like obtaining clean energy from space, mining asteroids for useful raw materials, creating secure locations for science experiments, recycling or sequestering valuable but hazardous debris already in orbit, harvesting water sources already in orbit, decoupling into oxygen and hydrogen for space fuels and oxidizers, and finally, providing radiation shielding mass (Greason & Bennett, 2019). Pharmaceutical companies, are evaluating the potential benefits of microgravity in the development of novel medication therapies that will help people live longer, healthier lives by performing studies in low-Earth orbit aboard the International Space Station. In an effort to produce more sustainable kinds of cotton, businesses are now getting involved. Companies such as Target are supporting research on the International Space Station (Clark, 2020).

Although many in the business are highly skeptical of space tourism, several new space enterprises like Blue Origin are striving to secure a piece of this enormous market. While active commercial research is being supported in the marketplace, the immediate and medium-term revenues from space manufacturing and asteroid mining will likely be insignificant. Ultimately, it is unknown if the infrastructure and less expensive access to space travel would lead to an economic incentive to stay in orbit, as current investors anticipate and hope (Weinzierl, 2018). Although space activities help the UN achieve its developmental goals, forecast the weather, and address climate change in novel ways, they also present security risks that need to be controlled. Systems in space and on Earth have historically fulfilled distinct purposes and needs. The idea behind this has changed as Earth-space networks have advanced in sophistication. In the future, satellite messaging for emergency communication in places without terrestrial connectivity may be included in smartphones (Klecha & Co., 2022). The number and complexity of ground control and

service support infrastructures are increased by large satellite constellations, increasing the attack surface. Critical services including emergency communications, utilities, aviation, and the military are provided by space services. They are therefore attractive targets for cyberattacks, particularly in times of geopolitical unrest (Ibid). Although there is a lot of discussion about this topic on a global scale, it seems that cybercriminals are constantly coming up with inventive ways to get around security measures and continue their illegal activity. It appears that in order for users of digital technology to identify and avert these hazards, a great deal of willpower and dedication are required (Baltezarević & Baltezarević, 2021).

CONCLUSION

All of humanity must be entitled to participate in the exploration and utilization of space, for the mutual benefit and in the best interests of all nations, regardless of the level of economic or technological advancement. Analyst projections indicate that the space sector will continue to grow steadily despite its current boom. The space economy covers a wide range of topics, including food, health, and pharmaceutical research as well as the use of satellite data to increase agricultural resilience to climate change. Although initial investment costs continue to be a barrier to entrance, many poor nations are already starting to participate in the space sector.

Government funding of space initiatives has a favorable effect on national economies. It fosters highly skilled employment, advances technology, opens up new business prospects, and boosts the economy overall. Consequently, this increases the amount of public funds available for addressing the world's most critical issues. The New Space Economy will undoubtedly contribute to economic growth in the years to come, as it is a strategic sector with the potential to give priceless opportunities across several production areas.

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