Space Commercialization is Closing the Digital Divide, but Expanding Global Economic Inequality

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Georgetown Journal of International Affairs, Volume 24, Number 1, Spring 2023, pp. 55-64 (Article)

Published by Johns Hopkins University Press
DOI: https://doi.org/10.1353/gia.2023.a897701

Business and Economics

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Space-based broadband internet could prove transformative for half of the world's population, who are currently without access to broadband internet. There is a risk, however, that the economic benefits from space exploration and exploitation will flow to just a handful of countries where commercial space companies are concentrated, chiefly the United States, further widening global economic inequality. While more multilateral mechanisms are warranted, countries should proactively engage in cooperation with leading actors, lest they miss out on the high economic growth resulting from the space economy.

Closing the digital divide, potentially disrupting government censorship

Commercial space companies, notably SpaceX's Starlink and OneWeb, are ushering in a new communication revolution,[1] with the rollout of space-based broadband internet that will soon be available everywhere on Earth. The companies are placing constellations of thousands and soon, tens of thousands, of satellites in low Earth orbit, offering broadband internet to 'everyone, everywhere.' For the four billion people around the world currently without any access to broadband internet, including rural and indigenous populations in North America, this could mark a transformative moment when they are connected to the information highway and have access to opportunities hitherto unattainable to them. Space-based internet thus has the potential to close, or at least narrow, the digital divide.

Indeed, direct access to space-based internet is likely to spur legal and technical efforts by some governments to maintain control.

Moreover, depending on the technology and its implementation, space-based internet has the potential to bypass national regulations and supervision if services are provided directly to the end-user, without a domestic intermediary or seeking a license from local governments. This may challenge countries' ability to censor and limit their citizens' internet access,[2] potentially providing hundreds of millions of people with access to information previously unavailable to them. China is already displaying discontent with Starlink. In an interview with the *Financial*

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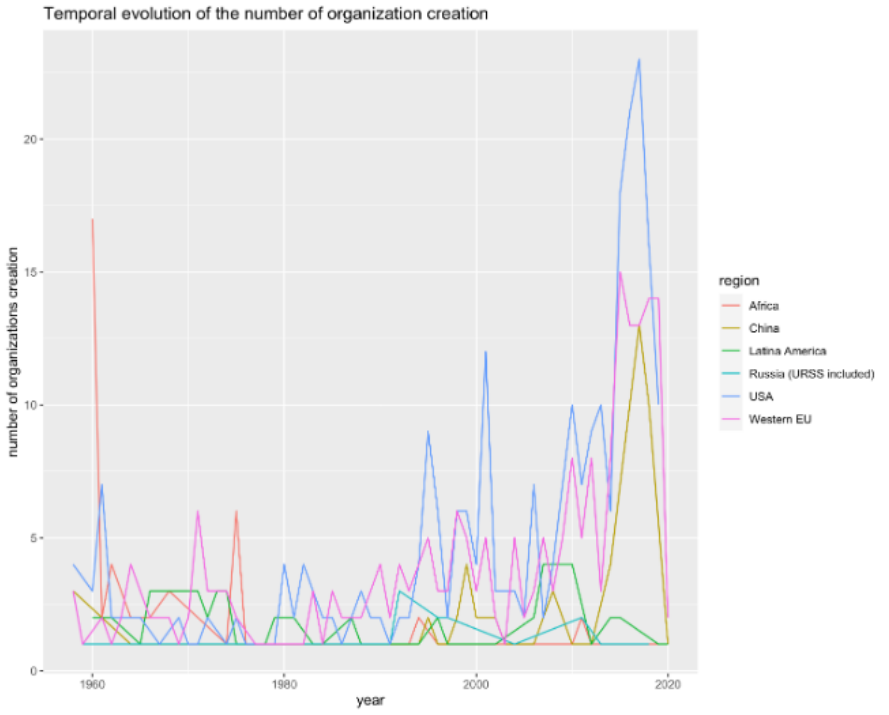
Times, Elon Musk, Starlink's founder, noted that Beijing sought assurances that he would not sell Starlink in China[3], and the Russian parliament considered fines for using Starlink.[4] Indeed, direct access to space-based internet is likely to spur legal and technical efforts by some governments to maintain control. Starlink demonstrated the geopolitical potential of space-based internet when it announced it is expanding coverage to Ukraine[5] amid the Russian invasion that disrupted regular internet access and again when it offered to provide Starlink access in Iran amid a government crackdown on demonstrations and internet use.[6] As governments worldwide deploy internet shutdowns and network disruptions to quell mass protests and reinforce autocratic rule,[7] internet access is a weapon in the fight for democracy.

Notwithstanding the social, economic, and political benefits of individuals around the world having access to broadband internet and information, space exploration also offers vast economic benefits. Yet only a handful of countries are positioned to tap into them, potentially leading to a significant expansion of global economic inequality. For most countries, cooperation with the leading spacefaring nations and commercial companies is currently the only way to also tap into the benefits of space exploration and exploitation. There is a high financial barrier to entry that benefits countries with well-budgeted space agencies and a strong private finance sector,[8] as well as critical technological barriers[9] and even regulatory entry barriers.[10] As a result, it is not feasible for countries that are new to space exploration and developing countries lacking significant funding and a strong, technologically advanced industrial base to go at it alone, if they wish to get meaningful outcomes. Such countries would need to actively pursue cooperation, and invest resources and attention in order for their countries to provide their citizens with the new standard of living that New Space will spark.

Graph 1. Number of New Space Organizations Established by year



Graph based on data from the Laval space governance dataset

The ultimate growth engine and its concentration in a handful of countries

The space economy is on a path of accelerated growth. The Space Foundation's Space Report 2021 Q2 states that it amounts to nearly half a trillion U.S. dollars globally, a fifty-five percent increase compared to a decade ago, and, significantly, that eighty percent of this is private sector activities.[11] Interim results from the analysis of the Laval space governance dataset show an explosion in the number of new space organizations established since the turn of the century,[12] and more so in the second decade of the century, with a tilt towards private sector organizations. The analysis further found that most of this growth is in U.S. organizations, with Europe second and China third, and with a significant gap between the three, while other regions and countries showed only minor growth (see Graph 1). The Space Report states that the United States represents nearly fifty-eight percent of global government spending on *civil* space activities. When combined with funding from China and European Space Agency countries, the number jumps to eighty percent. Given that the largest share of private investment in the space sector goes to the U.S.,[13] and that military space spending in the United States by far surpasses that of any other country, the share of the United States from the total investment in the global space sector is even higher. With the lion's share of organizations and investments concentrated in the U.S., it is poised to reap the majority of the benefits from space exploration.

A recent OECD report noted that there is growing evidence of the contributions of the space sector to economic growth and innovation and that space technologies will play a role in furthering social well-being and sustainable growth in the post-COVID-19 pandemic recovery.[14] The pandemic highlighted the importance of space-based applications, notably communication. Post-pandemic, we can expect to see increased public-private co-investments and partnerships, and even technology transfer to the private sector. This is expected to lead to accelerated growth of the sector, supporting other segments of the economy. Indeed, government investment still plays an important role in the development of space activities, including in support of the commercial space sector. Another important factor is a supportive regulatory environment, from streamlined regulation and licensing to the stipulation of clear rights and obligations. Interviews with industry leaders show that the U.S. has the most favorable regulatory environment.[15]

In addition to the already established and profitable traditional sub-sectors like satellite communication and remote sensing, the new sectors of space mining, tourism, and manufacturing, have yet to prove themselves, but carry a promise for enormous economic benefits.[16] Mining space resources may become the new 'Gold Rush.' NASA estimates that asteroids in the Asteroid Belt, a region of space between the orbits of Mars and Jupiter,[17] where most of the asteroids in our Solar System are found orbiting the Sun, contain resources valued around seven hundred quintillion U.S. dollars,[18] that is a million billion (ten^{18}). While the eventual economic potential is far less, considering the costs involved and the reduction of prices in the face of growing supply, there is a lot to gain for those who will pursue space mining. The two U.S. companies devoted to space mining, Planetary Resources, and Deep Space Industries, both encountered financial difficulties and were purchased by other companies who effectively seized their space mining activities.[19] The exorbitant cost might challenge more companies who try the same, but those who cross the finish line will reap enormous rewards, as estimates are that mining just the top ten most cost-effective asteroids (those closest to Earth and with the greatest value) would produce a profit of around 1.5 trillion U.S. dollars.[20] While dozens of countries use satellite communication, the number of those with domestic manufacturing of satellites is far less. Moreover, these new sectors are concentrated in a handful of countries, with a distinct concentration in the United States, greater even than the concentration seen in other high-tech sectors.

All told, the benefits of space activities and the riches of space will flow to a handful of countries, and of these countries, the lion's share will be concentrated in the United States.

All told, the benefits of space activities and the riches of space will flow to a handful of countries, and of these countries, the lion's share will be concentrated in the United States. To be sure, the 1967 Outer Space Treaty,[21] which serves as the 'constitution' of space, provides in Article I that "[t]he exploration and use of outer space…shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development." However, the decades-long debate on how this promise would materialize failed to develop a clear path forward,[22] as developed nations refused to adopt mandatory rules on the transfer of technology and the distribution of benefits from economic activities in space. Countries agreed only to the 1996 Space Benefits Declaration,[23] according to which "States are free to determine all aspects of their participation in international cooperation in the exploration and use of outer space…", maintaining discretion on those issues. A new proposal recently put forward by Professor Alexander Ezenagu, an expert on international taxation, envisions the adoption of a universal tax regime for outer space exploration as a way to ensure the distribution of space benefits globally.[24] According to the proposal, all countries will share the costs of space exploration, bearing responsibility for a portion of costs, based on their respective Gross Domestic Products, and will consequently be entitled to an equitable share of the benefits from such exploration. Still, to date, there exists no multilateral mechanism for the sharing of space benefits.

Yet, all is not lost. While rich countries have an advantage in obtaining space benefits, small and even comparatively poor countries can also gain access to these benefits. Cooperation with leading spacefaring nations can leverage local financial and technological capabilities, as the case of Israel demonstrates.[25] By far the smallest spacefaring nation (having domestic space launch capabilities), Israel conducts joint projects with NASA, the European Space Agency (ESA), as well as individual European states, India, Japan, Canada, and Mexico.[26] Furthermore, it has a framework agreement with the State of Florida by which both parties provide financial support for select joint projects from Floridian and Israeli commercial space companies. By casting a wide net of cooperation, with deep cooperation with NASA and ESA, Israel leverages its financial resources and technological capabilities and engages in the mutual sharing of knowledge.

Two small, newly space-ambitious countries—the United Arab Emirates (UAE) and Luxembourg—rely on cooperation with advanced spacefaring nations and commercial corporations to catch up on capabilities and take part in cutting-edge projects, including space mining and future Mars missions. The UAE Space Agency was established in 2014, and despite its infancy, has already launched a mission to Mars, thanks to the collaboration with U.S. partners. The mission took off from NASA's Kennedy Space Center atop SpaceX's Falcon 9 rocket, in a lunar lander designed by the Japanese company iSpace. The UAE also signed the Artemis Accords in order to join NASA's flagship Artemis Program to establish a self-sustainable habitat on the Moon. Notably, a UAE astronaut is on track to be part of NASA's SpaceX Crew-6 mission to the International Space Station in 2023.[27] These quick and impressive achievements could not have materialized without close cooperation with the U.S.

Luxembourg's 2020 to 2024 National Action Plan for Space, Science, and Technology emphasizes the importance of international collaborations.[28] The Luxembourg Space Agency represents Luxembourg in the European Space Agency (ESA) and space-related programs of the European Union.[29] Furthermore, to pursue its ambition to become Europe's hub for space mining, it agreed in 2016 to buy a major stake in U.S.-based asteroid miner Planetary Re-

sources,[30] and in 2020, it partnered with another such U.S. company, Deep Space Industries, for the same purpose.[31] If these two fairly rich countries rely on international collaborations to achieve meaningful space exploration and use, developing countries' ability to execute meaningful space exploration and use is even more dependent on collaboration with leading spacefaring nations. For countries with much less extensive financial resources than the UAE and Luxembourg, international collaboration could bring not only a technological jump-start but also a financial one. They can involve themselves in space commercialization via international cooperation, as in many cases leading space powers offer financial support in addition to technology, whether motivated by generosity or soft power, like China's support for space programs in Latin America.[32] Unlike hard power—a country's ability to coerce nations via military or economic means—soft power is its ability to attract and persuade, emanating from the attractiveness of its culture, political ideals, and policies.[33] And with space activities gathering worldwide attention and sparking the imagination of hundreds of millions, they serve as a tool for soft power by the U.S., Russia, Europe, China, and India.[34] For example, NASA brings in other countries and foreign organizations as partners on its flagship Artemis Program to establish a self-sustained habitat on the Moon,[35] with the explicit goal of reaching and inspiring audiences in new ways.[36] China declared it will open its space station to all UN member countries, as well as provide scientists from around the world the opportunity to conduct their experiments onboard the station.[37] The planned joint Russia-China moon base is a demonstration and declaration of their tightening bilateral relations.[38] China built and launched Venezuela's first remote sensing satellite[39] and invested fifty billion U.S. dollars in building a space center in Argentina to be used to send a rocket to the dark side of the moon.[40] China also has long-term space cooperation with Brazil, which it hails as an excellent example of South–South cooperation.[41] When leading spacefaring nations provide assistance to developing countries to develop their space programs and invite them to participate in projects they lead, they increase their influence over them or their own soft power.[42]

In addition, the UN Office of Outer Space Affairs (UNOOSA) has extensive capacity-building activities aimed at developing countries, with a variety of training modules on space science, technology, and even law.[43] These capacity-building activities include training in basic space science, basic space technologies, and human space technology. They also include training in disaster management and emergency response using space-based data. They further include efforts targeting specific groups, notably advancing empowerment efforts through the Space4Women Project and a new endeavor that focuses on persons with disabilities.[44] UNOOSA also co-organizes workshops on space law held, amongst others, in Argentina, China, Thailand, Iran, Ukraine, Nigeria, and Brazil.[45] Moreover, leading actors may have their own capacity-building outreach. China, for example, offers space science and technology education to students from member countries of the Beijing-led Asia Pacific Space Cooperation Organization (APSCO).[46] Countries are advised to use these offerings to advance their capabilities, especially those offered by the UN, since these come with no political strings attached, unlike support from nation-states.

Another inequality in the distribution of space benefits stems from the underrepresentation of women and other minority groups. The previously referenced OECD report also points to a gender gap in the space sector, and space law professor Cassandra Steer of the Australian National University argues that there is an underrepresentation of women at all levels of decision-making in space governance.[47] It is fair to assume that there are other underrepresented groups in the space sector as well. Some progress has been made, however, as currently, many of the heads of the Canadian space sector are women, including the President of the Canadian Space Agency (CSA) and the Chair of the National Space Advisory Board, and NASA had its first black Administrator, former astronaut Charles F. Bolden, during the Obama Administration.[48] These diversification efforts should continue, both to ensure basic principles

of equity are present in the government and private sector and also to ensure the best talent is present in this vital sector.

Although Indigenous populations around the world stand to gain from access to broadband internet, the satellite constellations that make that possible will have a negative impact on the field of astronomy, as well as on Indigenous traditions and cultural practices

The adverse effects of space commercialization are also unequally distributed. Although Indigenous populations around the world stand to gain from access to broadband internet, the satellite constellations that make that possible will have a negative impact on the field of astronomy, as well as on Indigenous traditions and cultural practices.[49] Here, too, there is more to be done. Vkatesan et al. suggest that Indigenous knowledge can support astronomy, one of the oldest human sciences, which is grounded in the cultural and scientific practices of Indigenous peoples worldwide. They share models of partnering with Indigenous communities as well as recommendations for U.S. funding agencies and institutions that will promote a more sustainable and inclusive scientific enterprise and our future.[50] Moreover, as the author and Prof. Whitehead suggest, Indigenous philosophy and concepts may provide a sustainable and efficient governance framework if applied to the moon and other space resources and to space habitats. The Māori worldview and legal tradition see "mana,"—a concept that has no direct Western equivalent but may be described as recognizing legal standing—in both human beings and the natural world. The New Zealand Te Urewera Act of 2014 recognizes the mana of the Te Urewera National Park and grants it legal personality, establishing it as something like a common-law corporation. This is the first statute in the Western legal tradition to grant legal personality to a natural resource. The authors analyze the resulting governance model through the lens of the theory of Nobel Laureate Elinor Ostrom and her design principles for managing common-pool resources. They envisage a scenario of applying the model—adapted using Ostrom's theory—to the Moon, other space resources, and space habitats and demonstrate that the model holds promise for efficient and sustainable governance.[51]

Conclusion

The commercialization of space will help narrow the digital divide by providing billions of people around the world with access to broadband internet and uncensored information. However, it will also dramatically increase global economic inequality, as the richest countries will experience an economic leap that many countries will miss. In the absence of mandatory multilateral mechanisms for technology transfer and distribution of space benefits, it is left to individual countries to allocate resources and attention to space exploration, utilize capacity-building opportunities provided by the UN, and actively pursue cooperation with leading spacefaring nations, in order to have a share of the pie.

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