DOI: 10.1111/ecaf.12676

DISCUSSION

ECONOMIC AFFAIRS WILEY

The value of space activity

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1 | INTRODUCTION

It seems likely that human beings have found space valuable, at least as a source of intrigue, since long before anyone knew much about what exists beyond the Earth's atmosphere. It's only since the 1960s, however, that people have been up there, doing things. In this article, I'm going to discuss 'space activity' in a broad sense, encompassing not only people and man-made machines doing things in space, but also the resource production and use that enables this. In particular, I'll focus on the value of space activity – again, on a broad conception of 'value'.

I'll begin by discussing the financial value of space activity: first, in the direct sense of its monetary value, in the context of calculations about the current and potential future size of the space economy; and second, in the derived sense of the good that can be brought about through the spending of the money raised through this kind of economic activity. Next, I'll turn to ways in which space activity furthers the human good: that is, how it can bring about things that are objectively and irreducibly good for human beings. Here, I'll focus on happiness and knowledge – discussing, for instance, the way in which knowledge about space is both valuable in itself and can also assist in meeting valuable societal goals, such as medical progress and peace. Finally, I'll briefly discuss space activity as a source of non-human value, in the sense of the good it can bring about for non-human animals, other living things, and natural resources.

2 | THE MONETARY VALUE OF SPACE ACTIVITY

Discussion about the current and potential future monetary value of space activity is focused on calculations about the 'space economy'. What this term refers to is contested, particularly in terms of its scope. However, on a 'widely adopted' definition, provided by the OECD in the first edition of its *Handbook on Measuring the Space Economy*, the 'space economy' refers to "the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilising space" (OECD, 2012, p. 3). In the recent second edition of the handbook, however, the OECD implies that whilst providing a satisfactory definition of the space economy was "challenging" back in

2012, subsequent developments have made this task even harder; in particular, "the line between space and non-space activities is increasingly difficult to assess" (OECD, 2022, p. 15).

This line-drawing problem is evident across attempts to quantify the monetary value of the space economy. And, as the Institute for Defence Analyses (IDA) emphasises, whilst employing expansive definitions can be useful for some purposes, doing so bears risks here: calculations totalling the size of the space economy "that include downstream activities [that are] not directly related to activities in space may", for instance, "mislead policy makers" (Crane et al., 2020, p. 2). The World Economic Forum attempts to mitigate this problem by dividing the space economy into its "backbone" and its "reach" – on which the "backbone" encompasses "space applications" with revenues that "accumulate directly to space hardware and service providers", whereas the "reach" encompasses those where "space is playing a key role in enabling companies across industries to generate revenues" (WEF, 2024, p. 9).

Other useful distinctions applied within assessments of the size of the space economy include the following four. First, economic activity is often divided into sectors, whether these are product-focused (e.g. the difference between satellites and rockets) or goal-focused (e.g. the difference between communication and Earth observation). Second, it is often divided into commercial activity and government activity, in terms of both the production of goods and services and the consumption of, and investment in, these goods and services. Third, the space economy and its component 'space systems' are sometimes divided into segments based on location or function: as taxonomised on the *New Space Economy* site, these segments typically include: space, launch, user, link, and ground (*New Space Economy*, 2023). Here, examples of everyday technology sometimes included in the "ground segment", such as car satnavs, show particularly clearly the blurred line between what counts as 'space' and 'non-space'. Finally, the IDA purposefully takes a "more targeted" approach in which the space economy is divided into four expenditure-focused categories: (*a*) government spending on activity in space; (*b*) household and business spending on services "generated in space"; (*c*) the sales of space goods and services, such as satellites and launches;[1] and (*d*) the sales of products required to "utilize space services", such as satellite TV dishes (Crane et al., 2020, p. iii).

This context helps to explain why calculations of the 2016 size of the space economy ranged from $166.8 billion, on the IDA's approach, to $350 billion, according to both Morgan Stanley and Merrill Lynch/Bank of America (OECD, 2022 p. 20). This context should also be taken into account when considering the WEF's recent calculation that the current size of the space economy, on 2023 figures, lies at over $600 billion (WEF, 2024, p. 4).

Complications of scope aside, however, Paravano et al. (2023) categorise the current space economy's main value streams as: exploration, observation, satellite navigation, and satellite communications. Indeed, the satellite industry is widely accepted to be an extremely important player,[2] with telecoms deemed a crucial "near-term focus" (Morgan Stanley, 2022), and "low-Earth-orbit applications", in particular, the most significant business opportunity (Menez, 2022). Currently, there are almost 10,000 satellites orbiting Earth (Elefteriu, 2024, p. 4), and the Satellite Industry Association calculates that the commercial satellite industry is worth almost $300 billion and "accounts for 71 per cent of the world's space business" (SIA, 2024).

Other standard claims about the current space economy include the following four.

First, that almost 80 per cent of the space economy's financial value is found in "commercial space products and services" (Bank of America Institute, 2023, p. 2). Second, that a "dramatic" reduction in payload costs has broken down market barriers, enabling not only new entrants but also the introduction of "new ideas and business models" (Menez, 2022). Third, that whilst the space economy is playing an increasing part in everyday life (again, particularly owing to the widespread adoption of satellite technology), there remains much more value for everyday consumers to realise (Paravano et al., 2023). And fourth, that, particularly in richer countries, various "critical infrastructures" beyond communications are increasingly dependent on "space capabilities" (Menez, 2022), and that this has important implications for national strategy and defence (Elefteriu, 2024), as well as commercial activity.

It is universally assumed that the space economy will continue to grow over the next decade. The WEF, again employing an expansive approach, estimates that its size will reach between \$1.4 trillion and \$2.3 trillion by 2035 (WEF, 2024, p. 23). It's worth noting, however, that assessors making predictions about the future size of the space economy typically admit to omitting certain likely and plausible costs and risks from their calculations — particularly costs and risks relating to societal impact and change. The OECD (2022, p. 113) goes as far as to claim that "the potential negative effects of space programmes on the business enterprise sector overall and/or on society as a whole are rarely discussed in evaluations of the space economy".

Nonetheless, and as largely reflected in the WEF's neat summaries (WEF, 2024, pp. 5, 23), assessors broadly agree upon core financial risks to the growth of the space economy (including changes in demand and regulation, the broad costs of accidents and disasters, and international political uncertainty, lack of collaboration, and unrest), and upon its core financial opportunities (including cost reductions, as well as growing rates of innovation and general intrigue). Beyond this is awareness of calculatory complications, such as instances in which risks provide financial opportunities, including the growing demand for private companies to tidy up "space junk" (Morgan Stanley, 2022), and the particular difficulties involved in attempting to predict future international political settlements.

Further standard predictions about the future of the space economy include the following five. First, that the space economy will increase as a proportion of the global economy (WEF, 2024, p. 4). Second, that it will become even more focused on communications (WEF, 2024, p. 23). Third, that there will be an increase in the range of investors, including growing institutional investment (Menez, 2022). Fourth, that space futures markets will expand (Menez, 2022). And fifth, that the number of countries actively involved in the space economy will continue to grow. There's also much discussion about the ongoing relevance of the state. It's generally assumed that state spending will continue to be "the cornerstone" of the space economy (WEF, 2024, p. 4), and that state incentives (including grants, procurement opportunities, prizes, and policy targets) will continue to have a significant impact, as will broader legislative and regulatory developments (see, for instance, the recent enaction of the American CHIPS and Science Act, and the EU's development of a European Space Law).

Finally, it's worth noting that previous estimates significantly underestimated the then-future size of the space economy: according to the Bank of America (2023), the space economy's size in 2021 was "up over 60 per cent from estimates just a decade prior". It's also worth remembering, however, what's been described as the "wildly missed revenue projections" (Rainbow, 2024) of the space-focused special purpose acquisition companies (SPACs).

3 | SPENDING SPACE-ECONOMY MONEY ON GOOD THINGS

Beyond calculations about the current and potential future monetary value of space activity is acknowledgement of the good this economic activity can, and does, bring about. I'll discuss below ways in which, for instance, space technology can be used to alleviate Earthly problems and how space activity can further the pursuit of knowledge. But financially, the good of space activity pertains to the good things that the money it raises are spent upon, whether profits or tax revenue, and whether this spending is optional or state-mandated. In other words, if space activity grows as a part of human life, and space continues to offer up new ownerships and new markets, then individuals, groups, and humanity as a whole will gain increasing opportunities to benefit through space-economy money being well spent, in space and on Earth.

That space activity remains extremely new, however – and that developments continue to happen apace – complicates questions about the distribution of many of the valuable opportunities the space economy offers. Does it matter, for instance, that such a small number of people, from a small (albeit fast-growing) number of countries, can directly take part in space activity? Whilst 77 countries now have space agencies (Space Crew, 2024), and satellites are reported to be "registered in 105 countries or multinational organizations" (Nanoavionics, 2023), only 23 countries have been represented by individuals visiting the International Space Station (NASA, 2024), and only 16 have launch capabilities (Space Crew, 2024). By 2021, the number of people who had spent time in space was only 570, the vast majority of whom were American (Mathieu & Roser, 2023).

And what about any economic activity, per se, that these people undertake, whilst they are in space? That is, what about any work they do, or what about any (space or Earthly) resources they consume or otherwise appropriate? How should these activities be regulated? Questions arise about the assignment of legal property rights, about fair and productive approaches to taxation, and, at a meta-level, about who should govern what. These are classic questions, with empirical as well as normative dimensions, which apply to all kinds of economic activity – but, clearly, there are added complexities here.

This is not least because space activity is currently governed by international law, which is ill-equipped to deal with certain developments of the space economy. As noted above, states remain, and are predicted to remain, the biggest space players, but commercial actors are playing an ever-growing role. And whilst individuals and firms do face some legal obligations under international law,[3] primarily it binds nations. Financially, a key governance consideration relates to the relevance of the inputs of space-created wealth – the resources that have been used, the labour and capital that have been expended – and how this should affect regulation, taxation, and access to opportunity. As yet, this topic is not sufficiently high on any political agenda. And appropriation, at least of the 'physical domain' of space, remains outlawed by the 1967 Outer Space Treaty (see e.g. Hertzfeld et al., 1979, for discussion of the long-running debate over the treaty's interpretation), although various attempts are under way to reform this through peremptory-norm change. For instance, as I've discussed elsewhere, "NASA has been criticised by some, particularly in competitor countries, for seemingly using the [Artemis] Accords to push a [jus cogens] norm in favour of American interests (or, at least, the interests of players with strong current access to the moon), particularly regarding the matter of ownership" (Lowe, 2022a, p. 18).[4]

Within this context, as I've argued before, there's a short time left for humanity to collectively institute an effective and morally justified system for assigning legal property rights in space, if we want to avoid the standard problems of an informal first-come-first-served system, which could see the most valuable space opportunities permanently monopolised by billionaires and autocrats (Lowe, 2022a; for recent context, see Elon Musk's September 2024 announcements about SpaceX's planned crewed flights to Mars – Wall, 2024). Such a situation would be problematic not only in terms of value considerations such as freedom and fairness and equality; it also seems likely that the ensuing lack of competition would represent serious opportunity cost, and could lead to highly limited outcomes.

One alternative approach, I've argued, would be to establish a framework to enable individuals and groups to acquire time-limited conditional legal property rights to plots of spaceland, on a Georgist-inspired market system (Lowe, 2022a, 2022b). On my approach, competitors would keep the full profit they made from the permissible use of their plots[5] but competition for the temporary ownership of these plots would consist in paying 'rent',[6] the rate of which would vary depending on supply and demand, and would be partially rebated in relation to the meeting of various conditions inspired by the Lockean property provisos of 'enough and as good' (e.g. if the use of spaceland contributed to poverty alleviation) and 'spoilage' (e.g. if the use of spaceland contributed to conservation efforts). This rent would be paid into a fund administered to enable an increasing number of individuals and groups to compete for plots, through investment in space innovation.

4 | SPACE ACTIVITY AS FURTHERING BASIC HUMAN GOODS

I'm now going to turn to some ways in which space activity can further basic human goods. There are various approaches to conceiving of such goods, but I'll take a simple conception on which there are multiple things that are generally and irreducibly objectively good for human beings qua human beings – things like knowledge, achievement, and friendship. This isn't to deny the importance of subjectively valuing objectively valuable things. Or to deny that finding satisfaction in such things, in the form of happiness, is objectively good for humans: indeed, I'll discuss it below, largely as such. But it is to assert upfront that a hedonistic conception of the good, on which the good reduces solely to happiness, or pleasure or preference satisfaction, is an overly narrow account.

There are also various approaches to determining and cataloguing the range of basic human goods (for a useful overview see Murphy, 2019). For current purposes, I'll focus on happiness and knowledge as examples of such goods, and consider some ways in which space activity can further these particular goods. In this context, I'm happy to assert that whilst assessing moral value in terms of basic human goods is sometimes seen as an approach peculiar to the natural law tradition, nonetheless finding objective value in happiness and knowledge is a deeply intuitive idea, evidence of which can be found (implicitly if not explicitly) within most accounts of morality, even though there are many differences between such accounts over different-order matters. In other words, beyond complex meta-ethical debate, it seems uncontroversial to conceive of happiness and knowledge as 'good for' human beings, and space activity as offering distinct opportunities for furthering these good things.

4.1 | Space activity as a source of human happiness

I'll begin by briefly discussing space activity as a source of human happiness. Beyond the happiness that can derive from, for instance, the spending of space money on meeting valuable goals such as medical progress, this can be seen most clearly in the accounts of people who have spent time in space. Indeed, it made headline news when William Shatner returned from space and claimed that the experience made him feel sadness and grief; that he found, looking into the darkness, "no mystery, no majestic awe to behold" (Shatner, 2022). More typical accounts involve emotional descriptions of deep feelings of happiness. Whilst on board the International Space Station, for instance, the Italian astronaut Samantha Cristoforetti tweeted an ancient Chinese text, which she translated as, "Looking up, I see the immensity of the cosmos; bowing my head, I look at the multitude of the world. The gaze flies, the heart expands, the joy of the senses can reach its peak, and indeed, this is true happiness" (Wei & Siqi, 2022).

Expressions of such happiness are familiar, as are those of great wonder and satisfaction. I'm not suggesting here that wonder and satisfaction are the same as happiness, but rather that, as nearby concepts, they often coincide with and contribute to it. And that even the indirect 'experience' of spending time in space – as an engaged spectator on Earth – is widely acknowledged to bring about these kinds of feelings. Space activity is regularly described as an 'achievement of humankind'; a core reason for expensive state spending on space programmes is to engender national pride and unity.

On the other hand, spending time in space poses extreme risks to human well-being. For some, such as the fighter-pilot astronauts with the crazy kind of bravery that Tom Wolfe (1979) describes as 'the right stuff', this danger adds an exhilarating edge to the happiness of experiencing space. For others, including the families of those astronauts, it can provoke unhappiness, fear, and even trauma. Indeed, whilst space programmes clearly bring happiness into the lives of many on Earth who vicariously share in the experience of space activity, there are significant contrary cases. Watching the Challenger disaster live on television would have been the first time that many children witnessed human death: one psychological study into traumatic effects reports that "[s]hortly after the explosion, shuttle-related dreams were prevalent, especially on the East Coast, where they occurred at a rate of 62% [of the children interviewed for the study]" (Terr et al., 1999, p. 1539).

In this context – and the context of astronauts who, like Shatner, do not find happiness spending time in space – it is perhaps more straightforward to think about the value of 'experiencing space' in terms of objective human goods furthered by space activity that don't depend on their experients' feelings: for example, you don't have to feel as if you have made an achievement to have done so. An alternative approach is to look to something much broader than happiness, which is nonetheless dependent on positive subjective experience: the sense of fulfilment that comes from meeting one's valuable goals.

4.2 | The epistemic value of space activity

I'm now going to turn to the epistemic value of space activity. There's a distinction to be made here between the way in which space activity enables us to know more about space and the way in which space activity enables us to know more about non-space things. I'm going to set the former aside, however, and simply accept that it is good to know things about the whole of the world around us, and that space activity is necessary to a significant part of this.

Rather, I'll focus on the way in which knowledge acquired through space activity can help us to further valuable non-space-specific societal goals. As the WEF emphasises, "[b]eyond revenue generation, space will [over the coming decade] play an increasingly crucial role in mitigating world challenges, ranging from disaster warning and climate monitoring, to improved humanitarian response" (WEF, 2024, p. 4). That is, progress made in the pursuit of space activity can be used to improve many kinds of useful Earthly technology, and innovative space technologies can also be used directly to help to address many problems on Earth. I'm going to focus, however, on two distinct domains in which knowledge acquired from space activity is currently particularly relevant: medicine and defence.

Space activity has contributed to medical knowledge since the days of the Space Race: it's well known that "the first biomedical data intercepted from space" was data recording the vital signs of the space dog, Laika (National Air and Space Museum, 2011); and Nilsson (2023) describes how the Apollo 11 astronauts "wore ECG sensors throughout the trip". In this context, the Association of American Medical Colleges (AAMC) explains how extreme conditions help with the development of personalised medicine, in the sense of helping to "tail [or] pharmaceuticals and other treatments for optimal effectiveness for a patient's unique physiology" (Balch, 2023). And Shirah and colleagues provide a useful overview of the breadth of medical advancement that has benefitted from space knowledge, including examples ranging from cooling treatments for joint treatments to improved CPR techniques and "tissue chip" experiments (Shirah et al., 2023). Similarly broad in range, NASA refers to progress in fields including dementia, asthma, cancer, and muscle protection, when discussing how "researchers from around the world use the space station to address complex human health problems on Earth" (NASA Space Station Research Integration Office, 2022).

In 2024 the space biotech company Redwire used its BioFabrication Facility technology, based on the International Space Station, to 3D bioprint the "the first live human heart tissue sample" (Redwire, 2024). And there are hopes for further advancements: the AAMC describes a "new golden age" of space medicine, in which, "to keep up with the demand for people with expertise in aerospace medicine, academic medicine institutions have expanded their programs to prepare clinicians for this burgeoning industry" (Balch, 2023). The increasing incidence of private space flight is contributing to this, an academic medic at the Center for Space Medicine explains, not only because it expands space activity, but because "[t]he private astronauts who go to space are more representative of the population on earth: older people, young people, folks with medical conditions, people from different countries" (Balch, 2023).

I'm now going to turn to two arguments focused on how space knowledge can bring about greater security on Earth – or even peace. First is a relative argument pertaining to the current international context. In his recent space policy primer, which offers "an alternative proposition for why space matters to the UK", Elefteriu (2024, p. 3) contends that the UK government should "view space as central to national defence", in the midst of the "rapid deterioration of the international environment" (2024, p. 5), and following a "step-change in worldwide space capabilities" (2024, p. 6). In this context, Elefteriu argues, increased investment in space activity is vital to making the nation secure against militaristic space threats (including alleged Russian plans for orbital nuclear weapons), as well as to pursuing strategic interests.

This argument, however, implicitly emphasises that space is also being used for offensive purposes. This is nothing new: the UN has been actively concerned with maintaining peace in space since 1957 (UNODA, 2018); the Space Race was always, primarily, a military project. But the Space Foundation (2024) has calculated that, in 2023, global military space budgets grew 18 per cent on the previous year, totalling $57 billion, and comprising almost half of total government space expenditure. And Euroconsult, which published similar figures, claims that 2023 was the first year in which more was spent on these military budgets (which it calculates at $58 billion, and describes as "defence expenditures") than on civil programmes (Euroconsult, 2023). Moreover, as Wiedemar (2023, pp. 1, 2) chronicles, ever since the first "integration of space-based assets into a military operation" during the 1990–91 Gulf War, the "militarization of commercial space assets" has developed at a rapid rate, and is "exemplified" by the role these assets are playing in the Russia–Ukraine war. In this context, whilst space activity may be proving increasingly crucial to protecting national interests, this development reflects the growing exploitation of space for aggressive ends.

The second argument is the more utopian contention that knowledge-based space-tech advances, in domains including observation and communications technology, could help to create conditions on Earth that are generally more conducive to peace. Central considerations here are ways in which improved access to reliable information could lead to fewer potentially catastrophic confusions, such as instances in which misunderstandings have almost led to the outbreak of nuclear wars (Sleight, 2016), and to greater accountability for power-holders committing wrongs, as seen in the case of satellite imagery proving the existence of the Chinese government's human rights-violating detention camps (Ruser, 2020). The value proposition here, therefore, is also largely focused on defence: that knowledge acquired in space will help to protect against, and ideally prevent, human aggression. Moreover, privacy concerns grow about increasingly invasive surveillance technology, and, whilst advances in communications technology can indeed help to reduce dangerous confusion, such advances also offer improved opportunities for collaboration between bad actors. In conclusion, whilst space knowledge holds much potential to further good ends on Earth – often offering privileged routes into doing so – the realisation of this potential will remain dependent on how such knowledge is used.

5 | THE NON-HUMAN VALUE OF SPACE ACTIVITY

Finally, I'm briefly going to discuss the non-human value of space activity. By this I mean the value of space activity to relevant non-human things, encompassing (*a*) non-human animals and other living things, such as plants and non-human extra-terrestrial life; and (*b*) natural resources, such as land, lakes, and the space vacuum itself. Much of what I've already discussed has relevance for the good of these non-human things. For instance, increased scientific knowledge can lead to advancements in veterinary medicine, as well as in the better surveillance and therefore protection of animal habitats, and in improvements for plant health and cultivation. And again, space profits and tax revenues can be spent on pursuing these good ends. But there are two further ideas that should also be taken into account when considering the value of space activity to these non-human things.

The first is the idea that space activity, when done well, can improve humankind's capability to conserve natural resources, on Earth and in space. Arguments coalescing around this kind of idea typically conclude that engaging with, using, and owning certain kinds of resources can make those resources more productive and better protected against harms. These arguments are often associated with historic 'homesteading' practices, which were not without significant moral and other problems (e.g. for a summary of the wrongs done to Native Americans by homesteaders, see National Park Service, 2021). On a more general level, however, conservation arguments track a basic human urge to protect the natural resources we live amongst – particularly in and around the places we think of as home – not only because these resources hold instrumental value for us, in using them, but also because we accord other kinds of value to them, such as beauty, historical significance, and intrigue.

A key objection to the conclusion that space activity could have important conservational benefits for natural resources in space, however, can be seen in the pressing problem of 'space junk'. As NASA (2023) bluntly puts it, "[t]he space around our planet is filled with rubbish". Inmarsat (2022, p. 5) claims that consequently "the risk of catastrophic accidental collisions is increasingly high". But space junk is not only hazardous to space activity and disadvantageous to astronomers; it also signifies a lack of respect for the environment. The existence of space junk doesn't necessarily defeat conservation arguments, however. Rather, it can be conceived as a free-rider problem, providing another reason for the urgent overhaul of space governance.

The second further idea to consider, when assessing the value of space activity to relevant non-human things, is less tangible. This is the idea that space activity could, one day, enable humankind to welcome other forms of life into our community – if there is such life in space for us to engage with. That is, the discovery of extra-terrestrial life could prove valuable not only for us but also for the extra-terrestrials. We could share with them our technological and cultural achievements, our friendship, and other good things. There are of course risks to consider here, too: both for us, if extra-terrestrial life were to prove hostile; and for the extra-terrestrials, if through bad behaviour or insufficient knowledge we posed a threat to them. But it is hard to avoid the temptation of considering the value of human space activity to life in places beyond our planet – and it is through such activity that we might gain the opportunity to engage with such life, on our own terms.

ENDNOTES

[1] To avoid double counting, the IDA omits figures pertaining to this third category from its calculations of the size of the space economy.

[2] Assessors taking the expansive kind of approach described above will weight the 'ground segment' more heavily than those taking an approach on which car satnavs and so forth are excluded.

[3] They are, of course, also bound by national laws and regulations, including, for example, launch licensing.

[4] As I discuss in Lowe (2022a), there are three standard ways to set about removing, or refining, the constraints of the Outer Space Treaty (OST) on appropriation: (*a*) persuade all countries to agree to a relevant update to the OST; (*b*) write a new treaty to supersede the OST, and persuade all countries to agree to this new treaty; and (*c*) develop a peremptory norm of international law (also referred to as a *jus cogens* norm), which would override the treaty's constraints. The UN states that *jus cogens* norms must be "accepted and recognized by the international community of States as a whole as a norm from which no derogation is permitted and which can be modified only by a subsequent norm of general international law having the same character" (UNGA, 2019, p. 142).

[5] My approach here follows the same kind of thinking that underpins Georgist land-value-tax approaches, on which what is taxed is the "base value of each piece of land that is owned, rather than … the value of anything that has been built or housed on that piece of land", on the grounds of fairness and equality as well as economic efficiency (Lowe, 2022a, pp. 35–7).

[6] It wouldn't technically be 'rent', in the standard sense, as it is wouldn't be paid to an actual owner or owners, since at least legally this land has never been owned, and the aim of the framework is to enable only temporary 'ownership'. Instead, the money would be paid into a fund administered for the good of humanity.

REFERENCES

Balch, B. (2023). The field of space medicine lifts off. *Association of American Medical Colleges News*, 6 July. https://www.aamc.org/news/field-space-medicine-lifts (accessed 16 September 2024).

Bank of America Institute. (2023). *The New Space Era: Expansion of the Space Economy*. Bank of America, https://newspaceeconomy.ca/wp-content/uploads/2023/08/expansion-of-the-space-economy-january-2023-3.pdf (accessed 16 September 2024).

Crane, K., Linck, E., Lal, B., & Wei, R. (2020). *Measuring the Space Economy: Estimating the Value of Economic Activities in and for Space*. IDA Science & Technology Policy Institute. https://www.ida.org/-/media/feature/publications/m/me/measuring-the-space-economy-estimating-the-value-of-economic-activities-in-and-for-space/d-10814.ashx (accessed 16 September 2024).

Elefteriu, G. (2024). *Why Space Matters to the United Kingdom*. Council on Geostrategy. https://www.geostrategy.org.uk/app/uploads/2024/04/GPPP02.Why-space-matters-to-the-United-Kingdom.pdf (accessed 16 September 2024).

Euroconsult. (2023). New Historic High for Government Space Spending Mostly Driven by Defense Expenditures. Euroconsult, 19 December. https://www.euroconsult-ec.com/press-release/new-historic-high-for-government-space-spending-mostly-driven-by-defense-expenditures/ (accessed 16 September 2024).

Hertzfeld, H., Weeden, B., & Johnson, C. (1979). How simple terms mislead us: The pitfalls of thinking about outer space as a commons. *Moon*, *18*, 1–11. https://swfound.org/media/205390/how-simple-terms-mislead-us-hertzfeld-johnson-weeden-iac-2015.pdf (accessed 17 September 2024)

Inmarsat. (2022). *Space Sustainability Report: Making the Case for ESG Regulation, International Standards and Safe Practices in Earth Orbit*. Inmarsat. https://www.inmarsat.com/content/dam/inmarsat/corporate/documents/corporate/insights/Inmarsat_Space_Sustainability_Report_2022.pdf.gc.pdf (accessed 17 September 2024).

Lowe, R. (2022a). *Space Invaders: Property Rights on the Moon*. Adam Smith Institute. https://www.adamsmith.org/research/space-invaders (accessed 17 September 2024).

Lowe, R. (2022b). Space is an opportunity to rethink property rights. *Reason*, December, https://reason.com/2022/11/15/space-is-an-opportunity-to-rethink-property-rights/ (accessed 17 September 2024).

Mathieu, E., & Roser, M., (2023). Space exploration and satellites. *Our World in Data*. https://ourworldindata.org/space-exploration-satellites (accessed 17 September 2024).

Menez, J., (2022). Exploring the business of space. *Yale Insights*. Yale School of Management, https://insights.som.yale.edu/insights/exploring-the-business-of-space (accessed 17 September 2024).

Morgan Stanley. (2022). 5 Key Themes in the New Space Economy. *Morgan Stanley*. https://www.morganstanley.com/ideas/space-economy-investment-themes (accessed 17 September 2024).

Murphy, M. (2019). The Natural Law Tradition in Ethics. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy*. Metaphysics Research Lab Philosophy Departments Stanford University. https://plato.stanford.edu/archives/sum2019/entries/natural-law-ethics/ (accessed 17 September 2024).

Nanoavionics. (2023). How many satellites are in space? *Nanoavionics Blog*, 4 May, https://nanoavionics.com/blog/how-many-satellites-are-in-space/ (accessed 17 September 2024).

NASA (National Aeronautics and Space Administration). (2023). Space Debris. 3 November. https://www.nasa.gov/headquarters/library/find/bibliographies/space-debris/ (accessed 17 September 2024).

NASA. (2024). Station Visitors. 25 March. https://www.nasa.gov/international-space-station/space-station-visitors-by-country/ (accessed 17 September 2024).

NASA Space Station Research Integration Office. (2022). Space Station Leads to Breakthroughs in Human Health on Earth. 23 July. https://www.nasa.gov/missions/station/space-station-leads-to-breakthroughs-in-human-health-on-earth/ (accessed 17 September 2024).

National Air and Space Museum. (2011). Laika's Heartbeat. https://airandspace.si.edu/multimedia-gallery/web11844-2011hjpg (accessed 17 September 2024).

National Park Service. (2021). Native Americans and the Homestead Act. https://www.nps.gov/home/learn/historyculture/native-americans-and-the-homestead-act.htm (accessed 17 September 2024).

New Space Economy. (2023). Space system segments: A quick overview. 2 February. https://newspaceeconomy.ca/2023/02/02/space-system-segments-a-quick-overview/ (accessed 17 September 2024).

Nilsson, A. (2023). Aiming for Mars – Curious about Space Medicine. Karolinska Institute, 19 January. https://news.ki.se/aiming-for-mars-curious-about-space-medicine (accessed 17 September 2024).

OECD (Organisation for Economic Co-operation and Development). (2012). *OECD Handbook on Measuring the Space Economy*. OECD Publishing. https://doi.org/10.1787/9789264169166-en

OECD. (2022). *OECD Handbook on Measuring the Space Economy* (2nd ed.). OECD Publishing. https://doi.org/10.1787/8bfef437-en

Paravano, A., Locatelli, G., & Trucco, P. (2023). What is value in the New Space Economy? The end-users' perspective on satellite data and solutions. *Acta Astronautica*, *210*, 554–563. https://doi.org/10.1016/j.actaastro.2023.05.001

Rainbow, J. (2024). SPAC class of COVID-19: Where are they now? *Space News*, 4 September, https://spacenews.com/spac-class-of-covid-19-where-are-they-now/ (accessed 17 September 2024).

Redwire. (2024). Redwire pioneering biopharma production in space by successfully bioprinting live human heart tissue and delivering second batch of PIL-BOX pharmaceutical crystal experiments. Redwire, 8 May. https://redwirespace.com/newsroom/redwire-pioneering-biopharma-production-in-space-by-successfully-bioprinting-live-human-heart-tissue-and-delivering-second-batch-of-pil-box-pharmaceutical-crystal-experiments/ (accessed 17 September 2024).

Ruser, N. (2020). There is now more evidence than ever that China is imprisoning Uighurs. *Guardian*, 24 September. https://www.theguardian.com/commentisfree/2020/sep/24/china-imprisoning-uighurs-satellite-images-xinjiang (accessed 17 September 2024).

Shatner, W. (2022). William Shatner: My trip to space filled me with 'overwhelming sadness'. *Variety*, 6 October. https://variety.com/2022/tv/news/william-shatner-space-boldly-go-excerpt-1235395113/ (accessed 17 September 2024).

Shirah, B., Bukhari, H., Pandya, S., & Ezmeirlly, H. (2023). Benefits of space medicine research for healthcare on earth. *Cureus*, *15*(5), e39174. https://doi.org/10.7759/cureus.39174

SIA (Satellite Industry Association). (2024). *State of the Satellite Industry Report*. SIA. https://sia.org/commercial-satellite-industry-continues-historic-growth-dominating-global-space-business-27th-annual-state-of-the-satellite-industry-report/ (accessed 17 September 20240).

Sleight, J. (2016). Seven things mistaken for an incoming nuclear attack. *Global Zero*, 26 May, https://www.globalzero.org/updates/seven-things-mistaken-for-an-incoming-nuclear-attack/index.html (accessed 17 September 2024).

Space Crew. (2024). Space Agencies Around the World. 8 March. https://spacecrew.com/blog/space-agencies-around-the-world (accessed 17 September 2024).

Space Foundation. (2024). Space Foundation Announces $570B Space Economy in 2023, Driven by Steady Private and Public Sector Growth. 8 July. https://www.spacefoundation.org/2024/07/18/the-space-report-2024-q2/ (accessed 17 September 2024).

Terr, L., Bloch, D., Michel, B., Shi, H., Reinhardt, J., & Metayer, S. (1999). Children's symptoms in the wake of Challenger: A field study of distant-traumatic effects and an outline of related conditions. *American Journal of Psychiatry*, *156*(10), 1536–1544. https://doi.org/10.1176/ajp.156.10.1536

UNGA (United Nations General Assembly). (2019). Peremptory norms of general international law (*jus cogens*). Chapter V, *Report of the International Law Commission*. Seventy-first session (29 April–7 June and 8 July–9 August 2019) (pp. 141–208). https://legal.un.org/ilc/reports/2019/english/chp5.pdf (accessed 17 September 2024).

UNODA (United Nations Office for Disarmament Affairs). (2018). Outer Space. https://disarmament.unoda.org/topics/outerspace/ (accessed 17 September 2024).

Wall, M. (2024). SpaceX will start launching starships to Mars in 2026, Elon Musk says. *Space.com*, 8 September. https://www.space.com/spacex-starship-mars-launches-2026-elon-musk (accessed 16 September 2024).

WEF (World Economic Forum). (2024). *Space: The $1.8 Trillion Opportunity for Global Economic Growth*. WEF. https://www3.weforum.org/docs/WEF_Space_2024.pdf (accessed 17 September 2024).

Wei, F., & Siqi, C. (2022). Italian female astronaut quotes famous ancient Chinese composition, wins praise on social media for excellent Chinese language skills. *Global Times*, 13 October. https://www.globaltimes.cn/page/202210/1277092.shtml (accessed 17 September 2024).

Wiedemar, S., (2023). The New Frontier of space militarization. *CSS Analyses in Security Studies*, No. 333, December. https://css.ethz.ch/content/dam/ethz/special-interest/gess/cis/center-for-securities-studies/pdfs/CSSAnalyse333-EN.pdf (accessed 17 September 2024).

Wolfe, T. (1979). *The Right Stuff*. Farrar, Straus, & Giroux.

How to cite this article: Lowe, R. (2024). The value of space activity. *Economic Affairs*, *44*(3), 561–571. https://doi.org/10.1111/ecaf.12676