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The Tragedy of the Common Space: On the Law & Economics of Commercialized Space Travel

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ABSTRACT: Space travel has a long history throughout the 20th century. Outer space exploration started with governmental endeavors in the 1950s and 1960s. During the cold war era, the so-called 'space-race' between the United States and the former Soviet Union led to major direct discoveries and accomplishments in outer space but also entailed indirect positive effects on the economy and society. Through the turn of the millennium, a new phenomenon started with a shift of former governmental space travel to offering private space experiences. In the most recent years, there has been a rapid advent of commercialized space travel options, which are expected to rise in scale and scope in the future. Privatized space travel has many short-term, medium-term and long-term advantages ranging from innovation sparking economic growth, first-mover advantages as well as leadership establishment. Conquering outer space on private sector tickets, however, may also entail various costs, risks and disadvantages that may or may not be obviously noticeable. For instance, in the short-term horizon, space travel is still a highly risky activity that can lead to fatal accidents and serious long-term health impairments. In the medium-term, space contamination and pollution have been reported as worrisome developments, which will exacerbate if space travel becomes commercialized and affordable to the global masses. The commercialization of space travel is also a legal and regulatory lacuna that bears risks of unforeseen political tensions, environmental degradation and human-ecosystem unbalancing. This article strives to inform a broad range of space travel stakeholders – like politicians, regulators, global governance executives but also non-governmental, private sector actors – about potential opportunities as well as risks of commercialized space travel. The article is organized as follows: An introduction will briefly touch on the historical advent and preliminary attempts to regulate and control space travel as well as economic problems arising to classify space as a common good. The theoretical part will give a snapshot of the history of space law from an international law perspective with reference to similar cases, such as the law of the sea. The empirical analysis will offer a first attempt to conduct a law & economics cost-benefit analysis with discounting different time perspectives for space travel benefits and costs. The discussion closes with a prospect of future research opportunities on the law and economics of commercialized space travel.

KEYWORDS: behavioral economics, commercialization, commercialized space travel, common goods, cost-benefit analysis, discounting, law & economics, Liability Convention, Moon treaty, outer space, Outer Space Treaty, private sector, public sector, Registration Convention, space, space travel

Introduction

Space is considered as the final frontier in human exploration endeavors. Astronomy has been used to understand earth conditions ever since. Since the early 17th century, telescopes have evolved to capture outer space. Originated in the public sector, space technology was developed to explore outer space in flying objects and capsules. Space rockets enabling outer space voyages evolved during the mid-twentieth century. The so-called 'space-race' was primarily driven by national governmental efforts in conjunction with scientific research with the goals of human exploration, research advancement and developing military and strategic advantages (Roston 2015). Since the 2000s, a large part of the developed world has participated in outer space missions. The United States, Russia, European Union, Australia, China, India, Japan but also Arab countries have explored and utilized space. Since the mid-20th century, human missions have been sent into Earth's orbit and to the Moon.

While historically space travel emerged as public sector endeavor, most recently there is an advent of commercialized private sector space travel. When it comes to the physical exploration, human spaceflight most recently turned into a private sector endeavor as for its enormous market opportunities. Apart from uncrewed robotic space probes, human space travelers have become reality. Lunar tourism started with Dennis Tito as the first-ever space tourist, who traveled 8 days to the international space station in 2001 for 20 million USD.

This article concerns the history of space travel and the implications of a commercialization of space exploration. After an introduction to space travel and its history, the article offers a Law & Economics analysis of commercialized space travel. The paper closes with a prospect for future research opportunities in the realm of interdisciplinary space studies.

Space travel

The first flying objects for space travel started with Sputnik 1 in 1957, triggering the so-called 'Sputnik shock,' indicating the surprise of the Western world that the Soviet Union had successfully launched flying objects in space and thereby implicitly started the space race for outer space exploration. In 1961, Yuri Gagarin became the first human spaceflight passenger of the former Soviet Union. The United States landed a human crew on the Moon in 1969. The former Soviet Union launched the International Space Station in 1971. At that time, space exploration was considered a national endeavor of primarily public sector entities.

Current developments include the Artemis program carried out by NASA in the United States in cooperation with commercial spaceflight companies. Artemis has the long-term goals of a sustainable presence on the Moon and private companies building a lunar economy. Companies emerging to serve lunar tourism include Blue Origin, SpaceX, and Virgin Galactics. Axiom Space is planning to add a module to the International Space Station and Bigelow Commercial Space Station is in planning.

From an international law perspective, the *res communis* principle applies meaning that not one state or entity can claim outer space as its property. Outer space is thereby comparable to the Deep Seabed and Antarctica. The United Nations established a Committee on the Peaceful Uses of Outer Space (COPUOS) in 1959 after the first satellite launch of the USSR, which currently features 69 member states. COUPOS launched international law instruments to govern common space activities, such as, the Outer Space Treaty, Rescue Agreement, Liability Convention, Registration Convention, and the Moon Treaty.

International treaties and conventions consolidate the wish of the international community to keep outer space and its benefits a public good for everyone. The Outer Space Treaty, which is formally known as the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, is a multilateral treaty that forms the basis of International Space Law. With 114 nation states as participants, his framework for International Space Law restricts national appropriation in space. According to the Outer Space Treaty, the exploration and use of space shall be for the benefit of all countries. Article 2 of the Outer Space Treaty (1967) defines that "outerspace, …, is not subject to national appropriation by claim or sovereignty, by means of use or occupation, or by any other means." Outer space is seen as a "province of all [human]kind." The Treaty also establishes that all use of outer space should be peaceful and therefore limits military use of space.

The Moon Treaty (1979), which is officially known as *The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*, turns jurisdiction of all celestial bodies over to the participant countries, which are – to this day only 17 countries. The Moon Treaty bans any military use of celestial bodies and advocates for peaceful use of the moon. The Moon Treaty bans all exploration and uses of celestial bodies without the approval or

benefit of other states. The Moon Treaty thereby also asks for a moratorium on the commercial exploitation of the moon until an international regime is established to govern and guide commercialized space travel. Problematic appears in both Treaties that none of the major outer space conquering nations is part of the treaties.

The *Convention on International Liability for Damage Caused by Space Objects* is also known as the "Liability Convention." Starting in 1972, the convention currently has around 100 ratifications. The convention defines that states are liable for damage caused by their space objects on the Earth's surface or to aircrafts in flight. Payment of compensation is thereby a state responsibility.

The *Convention on Registration of Objects Launched into Outer Space* started in 1975 and has become known as the "Registration Convention." The Convention requires space-launching to register space objects in a central United Nations register. Registration is seen as a prerequisite for traceability in terms of the liability of nations for space activities.

International Space Law advocates for an equal right of all states to research celestial bodies. Scientific discovery and exploration results should be made available to all countries for research purposes. The environment of celestial bodies should be preserved and protected, and states must take measures to prevent accidental contamination. International Space Law also bans any state from claiming sovereignty over any territory of celestial bodies since space is considered as a "common heritage of mankind." Resource extraction and allocation should be made by international regimes only and sole ownership of any space property cannot be claimed. International Space Law also advocates for an international regime to govern the exploitation of space resources.

From an economic standpoint, the costs of outer space travel have historically been borne by individual nation states, but the profits generated oftentimes shared by society as a whole. The new age of commercialized space travel now raises questions about economic advantages but also potential downfalls of privatized space travel, as the costs may have to be borne by everyone. The focus of a common heritage of humankind in space creates a common good problem dilemma (Hardin 1968). The lack of private property claims or national acquisition of goods in outer space is believed to cause an impediment to the development of space travel and celestial habitation. Contemporary attempts to shift space exploration to a private sector endeavor, however, also bear risks and problems.

Law & Economics of Commercialized Space Travel

When analyzing the commercialization of space travel, a Law & Economics analysis can be conducted. When integrating a discounting element, the short-term, medium-term and long-term benefits as well as costs and risks can be identified in order to inform a broad-based stakeholder circle of politicians, regulators and global governance executives. The longer-term the implications of commercialized space travel are, the higher the depth of thought is advised to be.

On the short-term horizon, benefits of innovation in the space travel domain will likely push the economy as a whole. We already saw an increase in positive economic effects during the 1957 Sputnik shock in the US. After the USSR was first to send living creatures into space, the US invested in STEM fields in order to push for human capital being able to compete in the space race. This educational effort had a large-scale positive impact and inspirational character in very many different applied fields, such as engineering, finance, economics and medicine. Innovation also always leads to indirect effects and positive externalities as well. NASA programs are often associated with ongoing economic benefits (such as NASA spin-offs) that generate multifaceted revenues (Hertzfeld 2002). For instance, in the creation of space travel material, extraordinary hard and enduring material had to be invented, which was actually then used for teeth implants and crowns to replace broken teeth. Outer space also creates unlimited opportunities to test for living in various unknown

environmental conditions. From an economic perspective, moving to outer space expands the horizon of opportunities in the most unique way and grants unlimited opportunities to grow and advance. The beginning of international law emerged from the Law of the Sea, when different nations claimed parts of the ocean being their territory. International Law helped settle disputes and drawing clear lines how far oceans belong to adjacent nation states. Space Law may become the next area of international law development that sparks legal innovations to navigate common international conduct in outer space.

As for medium-term benefits of commercialized space travel, there may be a first-mover advantage of conquering space with the growing importance of space travel. In the claiming of resources of relatively unregulated space, those who come first can benefit from their first claim opportunities. The resources in outer space are estimated to be worth billions of dollars alone in the domains of minerals and metals (Elis 2012). Especially in the beginnings of space travel extractions in fairly unregulated territories will be possible. But also infrastructure can be built up that helps nations for intelligence purposes. For instance, satellites provide instrumental intelligence to monitor earth developments, environmental degradation but also support military operations around the world. In addition, the earlier entities engage in space travel, the better they can secure their positions in relation to others leapfrogging behind them.

As for long-term benefits of commercialized space travel, the actors that claim first-mover advantages will likely become leaders of monopoly or oligopoly regimes that divide the benefits of commercialized space travel among themselves. This leadership position will likely be grounded on the first exploration phase, in which regulation will be leaping behind. Based on tradition and specialization, the leading companies that invented commercialized space travel will have not only a leadership image. These corporations will likely also be able to foreclose the market or consolidate a leadership role with growing a large gap to competitors and new market entering participants. These leaders-in-the-field will be able to sell their key knowledge and information they gain from their role in space. The leading companies may also benefit long-term from reusable spacecrafts, knowhow and economies of scale that they will have built up during their advent to power.

When it comes to costs and risks of commercialized space travel, one has to acknowledge that traveling to space is still associated with heightened risks of accidents and health problems. During the 1986 Challenger event, when the Space Shuttle Challenger broke apart seconds into its flight, seven crew members were killed. The technical error was attributed to be somewhat foreseeable, yet the wish to explore and push innovation created a somewhat tunnel vision shunning researchers to rightly estimate the dangers of presented evidence of material weaknesses. To this day, space travel comes with health impairment as blood and immune system changes have been reported. Active space travel may lead to the space motion sickness syndrome and symptoms of vertigo, dizziness, fatigue, nausea and disorientation during the flight. Space travel can also adversely affect the body's natural biological clock and therefore cause sleep disturbances as well as mental and physical exhaustion (Doam, Polk & Shepanek 2019). Longer-term space excursions lead to bone and muscle weakening due to low gravity and immune system suppression as well as unhealthy levels of radiation exposure. Lack of gravity can cause all sorts of problems resulting in vision problems, loss of bone minerals and densities as well as cardiovascular deconditioning and decreased endurance and muscle mass (Perez 2016). Immune system changes after space travels are studied and documented, e.g., by a twin study, in which one twin flew to space and the other remained on earth. Radiation is associated with heightened cancer risks. Higher levels of radiation are prevalent in outer space when the Earth's magnetic field no longer protects from the sun's radiation. Traveling to space is also an emotionally burdening moment as psychological distress has been reported by space explorers. The European Space Agency has launched projects to reconnect humans in space via fragrances and scents that

remind of the earth to combat isolation from space. For instance, a report of a crew member sabotaging the toilet in order to be able to return to earth earlier exists. In addition, procreation appears impossible in outer space as experiments with mice have indicated fatal birth defects. Therefore, being in outer space is a short-term fertility impairment that needs to be considered when starting to sell vacation time in outer space to the population.

The medium-term costs and risks of commercialized space travel include the contamination risks but also environmental degradation through pollution. Astrobiology interdisciplinarily studies life in the greater universe and thereby combines astronomy, biology and geology to understand the interaction of human with outer space. Unknown contamination risks may exist as the question of the long-term implications of uncontrolled ecosystem exchange between the earth and space remains open if imposing a potential contamination hazard. When sea travel started in the 15th century, diseases were exchanged between the old and the new worlds. Unknowingly we may pollute and bring earth features to space or in reverse contaminate the earth with unforeseen space ecosystem biohazard. Space debris in outer space that remain in orbit forever have become an issue of concern for the worldwide community. Satellites stay in space forever and if they hit other objects, they burst apart in multiple parts that are uncontrollable. Commercialized space travel will likely exacerbate this problem. There is also the question of financing space travel with cryptocurrencies, e.g., as is the case with Marscoin. Cryptocurrencies have been attributed as somewhat risky market option and addressed as unsustainable as for energy-consuming mining operations. Funding commercialized space travel with cryptocurrencies will therefore likely impose environmental costs – not only for the pollution of space travel per se – but also implicitly the mining operations will take a toll on nature for elevated energy consumption levels.

As for the long-term negative impact of space travel commercialization in the broadest sense, private sector space endeavors are still fairly unregulated, which may lead to political tensions. To this day, if spacecrafts fly to outer space, the commercializing entities are flying the flag of the nation of their incorporation. This may lead to implicit political tensions, e.g., if a US corporation conducts risky operations that hurt a Russian space object. Most recently, space debris from a Chinese satellite caused problems to satellites from various other nation states, as another example. States may involuntarily be involved in legal disputes and liability regimes and responsible codes of conduct are still to be developed when it comes to space travels. Space colonization, also called space settlement and space humanization, also implies risks similar as detected in previous colonial times, which have negative implications for society to this day. On the long run, if commercialization leads to mass space travel and space travel prices thereby drop, the environmental pollution but also contamination hazards will increase. As for ethical considerations, involving private sector entities and allowing for standard market operations with limited oversight possibilities tend to crowd out attention to ethics and social responsibility. Future space travel commercialization regulation should be mindful of examples of corporations and outsourcing leading to ethical dilemmas and social welfare infringements. In the past, architecture studies, military operations and educational attainment held examples of private sector engagement crowding out ethics and social responsibility. Most recent positive developments to address inclusion in space include the formation of inclusive spaceflight watchdog organizations, such as the Justspace Alliance and Inclusive Astronomy, which mark an important step in the direction of ethical space conduct.

Discussion

Privatization is oftentimes acknowledged as a driver of growth and protection of goods, yet also often mentioned as an impairment for ethical considerations and long-term focus. This article addressed the potential of commercialized space travel as a way to create enormous benefits and values in the short-term, medium-term and long-term. Innovation pushing the economy and space exploration as a gateway to a new generation of international law

promises to hold unprecedented opportunities for humankind traveling into outer space commercially. Those who start with selling outer space travels will likely benefit from a first-mover advantage to conquer resources, claim space and learn for intelligence. The market will likely see an oligopoly formation for commercialized space travel supply, where the key leaders-in-the field have enormous economies of scale and price-mark-up advantages.

On the contrary one needs to be mindful of the potential hazards of mass space travel – such as accidents and health problems, contamination risks and pollution. The commercialization of goods and services has proven to lead to a neglect of attention to ethics and general safety precautions in the past. It is on humankind to curb similar negative developments that have happened in the political, environmental and societal spheres in the wake of privatized goods and services provision in other domains.

Future research may delve into international law predicaments in space with reflection on incentives and ramifications. An international regime for the governance of common goods in outer space must be resuscitated in order to address pressing legal, regulatory and political questions regarding space travel. Economic aspects of commercialized space travel, such as bonds schemes to secure funding streams but also licensing system to allocate costs and benefits among different stakeholders based on their input, could be discussed. Future scientific investigations may also delve deeper on the financialization strategies of space travel agents with particular attention to crowdfunding endeavors, e.g., via cryptocurrencies. Ethical market perspectives and imperatives such as Corporate Social Responsibility, Responsible Finance and Intergenerational Equity may become extended onto commercialized space travel in the future.

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