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Structuring the Discourse on the Exploitation of Space Resources: Between Economic and Legal Commons

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ABSTRACT

A critical discussion is reemerging in space policy, economics, and law: on the classification, use and possible ownership of space resources, and the governance of these activities in terms of rules and institutions. The US legislation from 2015, recognizing the right of US citizens to all asteroid resources they obtain, clearly signals that "money time" has come, in every meaning. Planetary Resources, Inc. has declared this new legislation "the single greatest recognition of property rights in history". Yet, the discourse on space resources, which are widely—but not necessarily duly—regarded as "commons", is unstructured and crippled by the confusion of the notion and essence of "commons" between the economic and the legal meanings. This article provides a critical analysis of the "commons" feature of outer space and outer space resources, based on economic analysis and legal theory. More importantly, this article seeks to provide the structure for this important discourse. The first critical step is to distinguish between (i) commons as an *economic* term and (ii) commons as a *legal* regime. The first refers to a type of goods or resource used by multiple users, and the second refers to a property rights regime, the ownership over the resource. A mistake, often made, is the confusion between the economic notion of "commons" and the legal sense of the same concept. An "economic commons", such as a lake, may have different property rights regimes as it may be private property, government property, or "legal commons". The second critical differentiation is between the different parts of space (e.g. orbits, celestial bodies, and void space) because some may be "commons" (economic and/or legal) while others may not. Asking whether "space" is commons wrongly puts numerous things in a single basket is a sweeping generalization and, in the economic sense, utterly meaningless. Another important distinction is between resource systems and resource units. If we get the questions wrong, i.e. by confusing the terms and mixing different subjects of inquiry, we will not, by definition, find the right answers. Furthermore, the article demonstrates that the notion of "global commons", often applied to outer space, is of limited or unclear meaning, and it does not imply the property rights regimes in the domains and resources it presumably describes, including outer space. The article opens with making the aforementioned three distinctions in section two. Sections three and five present, separately, the economic and legal notions of "commons" and examine whether some parts of space qualify as economic and/or legal commons, whereas section four presents the limitations of the notion of "global commons", thus leading to section five. The article concludes by connecting the economic and legal discussions to the search for appropriate governance models for each part of space. As the article demonstrates, the real questions in the discourse are much more complex than "is space commons?". Although this article provides preliminary answers to the questions it raises, its main contribution is the reshaping of the question(s) currently being asked and the structuring of the discourse on space resources and their governance.

1. Introduction: the (re)emergence of a discourse

A critical discussion is (re)emerging in space policy, economics and law: on the classification, use and possible ownership of space resources, and the governance of these activities in terms of rules and institutions.

The legal platform for space activities, the basic norms and principles and the five UN space law treaties, was created during the 20-year span between 1958 and 1979 and remained largely unchanged since then, apart from soft law. Our era of New Space, with a breadth of commercial space activities and applications, is

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pushing the boundaries of space law and putting a strain on this legal platform. In particular, the heated race toward the mining and utilization of space resources, the focus and *raison d'être* of two American companies (Planetary Resources and Deep Space Industries), has awaken the discussion on the regulation of such activities and the possible sharing of their benefits. The issue is not new. It was addressed in the 1979 Moon Agreement [1], and it was probably Article 11 thereof, promoting a framework for the regulation of the issue, that led many countries, and in particular the leading spacefaring nations, not to accede to this treaty. The reluctance of the spacefaring nations to accede to the Moon Agreement may be explained by their unwillingness to constrain their future activities or commit to what may be interpreted as a distributive regime. The general issue of the distribution of the benefits from the exploration and use of space has been debated for years [2]. The 1967 Outer Space Treaty (OST) [3], which establishes the basic norms of space law, provides that "[t]he exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind". After many years of debate, mainly along the North-South lines and also along the West-East lines, the 1996 Declaration on International Cooperation [4], referred to by some as the "Space Benefits Declaration", elaborated on the issue though left wide vague margins [2].

Meanwhile, the technological and commercial environment has advanced and the extraction of space resources is expected in the foreseeable future, yet there is no agreed normative framework in the international level to regulate it. In November 2015, the United States adopted the Commercial Space Launch Competitiveness Act [5], Chapter 513 of which—Space Resource Commercial Exploration and Utilization—recognizes the right of US citizens to all asteroid resources they obtain, a highly contested move which some claim to be contrary to the OST. The stated goal of the Act is to "facilitate a progrowth environment for the developing commercial space industry by encouraging private sector investment and creating more stable and predictable regulatory conditions, and for other purposes" [5]. Planetary Resources, Inc., an American company focused on developing and deploying technologies for asteroid mining, has declared this new legislation "the single greatest recognition of property rights in history" [6]. This is by no means an exaggeration. Goldman Sachs recently presented to its clients a detailed review which asserts that space mining could be more realistic than perceived. The review asserts that the costs have significantly decreased bringing them nearly in line with costs of mining on earth and just a third of the funds invested in Uber, well within the reach of the Venture Capital funds. The review further asserts that the potential profit from space mining is immense as just one asteroid might contain US$ 50 billion worth of platinum [7]. When the engineers will finish their part, the potential for immense profits is expected to launch a new "gold rush" (or platinum rush). Planetary Resources, Inc. envisages that "this [new US] legislation establishes the same supportive framework that created the great economies of history, and will encourage the sustained development of space" [6].

More actors are following suit. Moon Express, another US company, has a planned lunar mission and is the first private company in history to receive government permission to travel beyond Earth's orbit. The company has joined the space-mining race with its announcement that it seeks to mine the moon for valuable resources [8]. JAXA, Japan's space agency, signed a memorandum of understanding with a private company, Tokyo-based iSpace Inc., to establish an industry for the mining, transport, and use of resources on the moon [9]. Luxembourg has also joined the race, aiming no less than to lead Europe in the space-mining sector. Already home to one of the world's largest operators of communication satellites SES S.A. (*Société Européenne des Satellites*), Luxembourg has set aside € 200 million for space-mining operations [10], partnered with Deep Space Industries [11] and Planetary Resources [12]. Moreover, in July 2017, Luxembourg adopted a law regulating the extraction of space resources which recognizes that space resources are capable of being owned by private companies [13,14]. The United Arab Emirates (UAE) has also set the goal of asteroid mining [15] and is preparing national space legislation that will regulate this activity [16].

All this clearly signals that "money time" has come; the governance of outer space resources is being shaped now, with or without consensus among states. It is therefore important to study at this point in time the proper governance—norms, rules, and institutions—of space resources. Yet, the discourse is unstructured, and there is confusion regarding the most basic notions.

Indeed, there is an increase in scholarship on the issue[1] and there is also the Hague International Space Resources Governance Working Group, led by Leiden University's Institute of Air and Space Law [17]. It seems that the prevailing view is that space is commons, although the nature of this "commons" feature is not clear and surely not agreed upon even by those supporting it. Others argue that outer space is not commons [18].[2] Significantly, the United States, probably the most important actor in resource mining, seems to hold the position that space is not commons [49]. Claims that space is or is not commons are followed by assertions and conclusions derived from these claims. A claim that space is commons is likely to be followed by a conclusion restricting its use, a restriction that derogates from the freedom of exploration and use of outer space stipulated in Article I of the OST. Article I provides that outer space "shall be free for exploration and use by all States", and it is therefore important to ensure that this freedom is not restricted based on misunderstanding or misuse of the notion of "commons".

Despite the centrality of the notion of "commons" to the discourse on space resources, its meaning seems to evade many authors, which alternate between the economic and legal meaning and even combine features from both to a mélange of elements. In addition, it is not common practice to differentiate between the various parts of space and between resource systems and resource units, distinctions that may be unfamiliar to many legal scholars. Economists, on their part, often perceive property rights, another notion important for the discourse of space resources, in inconsistent ways that also deviate from its legal meaning. The lack of conceptual clarity and consistency cripples the discourse as there is no common base for the discussion. Instead, there is at least occasional erroneous or inconsistent use of the terms and features, which casts a shadow on the conclusions of such a discourse and thwarts cross-disciplinary discussion.

This article aims to suggest a structure for this important discourse by: (i) distinguishing between the legal and the economic notions of commons; (ii) differentiating between various parts of

[1] See, for example, Ricky Lee, *Law and Regulation of Commercial Mining of Minerals in Outer Space* (Springer 2012), Ram S. Jakhu, Joseph Pelton and Yaw O.M. Nyampong, *Space Mining and Its Regulation* (Springer. 2017), Fabio Tronchetti, The Exploitation of Natural Resources of the Moon and other Celestial Bodies; a Proposal for a Legal regime (The Netherlands: Martinus Nijhoff Publishers, 2009); Philip de Man, Exclusive Use in an Inclusive Environment: The Meaning of the Non-Appropriation Regime for the Exploitation of Orbits and Asteroid Mining (Springer 2016); Stephan Hobe and Philip de Man, National Appropriation of Outer Space and State Jurisdiction to Regulate the Exploitation, Exploration and Utilization of Space Resources, 66 ZLW (2017), 460–475; and Annette Froehlich, ed, Space Resource Utilization: A View from an Emerging SpaceFaring Nation (Springer 2018).

[2] At the 58th IISL Colloquium on the Law of Outer Space in 2015, Hertzfeld, Weeden and Johnson presented a paper claiming space is not commons [18]. The presentation spurred fierce comments from all leading space law scholars present, demonstrating the importance of the issue and that this position is probably in minority.

space (e.g. planets, void space, earth orbits, man-made spacecrafts); and (iii) differentiating between resource systems and resource units. The paper further aims to provide the foundations for the discourse by (i) presenting the notion of 'economic commons' and 'legal commons' and clarifying the meaning of property rights; (ii) by pointing the limited contribution of the notion of "global commons" to the discourse; and by (iii) connecting the economic and the legal. On the basis of this common language it will be possible to conduct a fruitful discourse on, and provide a critical analysis, inter alia, of the *lex lata* and *lex ferenda* regarding space resources and their utilization. In addition, this paper briefly examines whether some parts of space are economic and/or legal commons.

2. Structuring the discourse on the "commons" feature of space

Confusion and failure to distinguish between the economic and legal meanings of "commons" and between resource systems and resource units was prevalent also in the general debate on private versus common property. Elinor Ostrom, who was awarded the 2009 Nobel Prize for economic sciences for her research on the management of the commons, and Hess, whose research focus was on commons, noted that these confusions cloud the debate about the relative merits of private and common property and "reduce clarity in assigning meaning to terms and retard theoretical and empirical progress…" [19]. This section provides the dividing lines between the economic and legal notions of "commons", between the different parts of space that may or may not be economic and/or legal commons, and between resource systems and resource units.

2.1. Differentiating an economic feature from a legal regime

The first stop in delving into the meaning of the notion of "commons" is to distinguish between (i) commons as an economic term and (ii) commons as a legal regime, i.e. between commons as a resource (an object or a "thing") and commons as a property rights regime (and therefore an abstract, separate and different from the "thing" upon which they are projected). The first refers to a type of resource, one which is used by multiple users, such as a lake that is used by numerous fishermen. The second refers to a property rights regime, that is, the ownership over the resource, and denotes that the property rights are jointly held by more than one actor. A mistake, often made, is to alternate between "commons" in the economic and the legal sense.

It is crucial to differentiate between resources and the legal regime that governs them [20,21]. *It is likewise important to stress and reiterate that there is no automatic association between commons as an economic feature and commons as a legal regime* [19]. An "economic commons" may have different property rights regimes, not just "legal commons". The lake—an economic commons—may be state property, where the government grants fishing licenses, or privatized, where a single owner sells fishing licenses/quotas, and can also be community property ("legal commons") or owned by no one. Therefore, it is one thing to suggest that space is commons in the economic sense and another thing altogether to suggest that space is commons in the legal sense, and one does not even imply the other. *Being goods or a resource of a certain kind does not necessitate a single certain property rights regime* [19].

It should be noted, however, that there is a connection between the type of resource in the economic meaning and efficient governance thereof, governance that may be established or described in terms of a legal regime of property, as will be discussed in Section 5.

The next step is to put forward a full definition of economic commons and legal commons and examine if space, or any parts thereof, are economic or legal commons, bearing in mind that a positive answer to one does not necessarily entail a positive answer to the other and vice versa. Section 3 defines economic commons and examines whether space or parts thereof are economic commons, whereas Section 5 defines legal commons and examines whether space or parts thereof are legal commons.

2.2. Differentiating between the various parts of space

The second step in analyzing the "commons" feature of outer space is to separate the discussion and conduct an independent examination of each part of space to conclude if it is "commons" and derive its proper governance. By "parts of space" I mean areas, resources, and objects, natural or artificial, e.g. planets, asteroids, void space, earth orbits, and even man-made spacecrafts. It would be a conceptual mistake and a sweeping generalization to ask whether Earth is commons (economic or legal) as there is a difference between the open seas, private land, state-owned land, airspace, etc. It is likewise a sweeping generalization and, in the economic sense, utterly meaningless to ask whether space, an infinitely larger domain, is commons; to put planets, stars, void space, and orbits in one basket and ask if the content of the basket is commons. Each has its economic characteristics and is susceptible of being regulated by a different legal regime. Moreover, space today includes a large and increasing amount of artificial objects, e.g. satellites, probes, the International Space Station (ISS), and even space debris, which are already treated differently, not as "commons" but as under the jurisdiction of the state of registry. To be sure, outer space is commonly referred to as 'global commons', but as section 4 demonstrates, domains traditionally considered to be 'global commons' already have different property rights regimes as to specific benefits therefrom: the United Nations Convention on the Law of the Sea (UNCLOS) provides a different regime to fishery and the deep seabed, and the regulations of the International Telecommunication Organization (ITU) provide a regime regarding the geostationary orbit that is not applicable to the rest of space. And while OST Article I and II do not differentiate between outer space and celestial bodies, Article IV paragraph 2 does provide rules (on military uses) that apply only to celestial bodies, not to other parts of space, e.g. void space.

The question whether space is commons must therefore be replaced with more specific questions that distinguish between the various parts of space. One may ask whether the moon is commons or even whether planets in general are commons, but one should not ask whether "space" is commons. Examination whether a part of space is commons may be conducted regarding a single part of space, e.g. about the geostationary orbit or about categories of parts of space, e.g. about earth orbits (which include the geostationary orbit, low earth orbit, and high earth orbits) and resources (e.g. helium, platinum, water). However, even the use of categories needs special care as there may be variations in a single category. For example, the geostationary orbit is highly congested, but other orbits are not, which means that the various earth orbits feature subtractability and others not, with effects on their classification, as we shall see in Section 3.2. We cannot ask this question regarding celestial bodies as they include asteroids, moons, planets, and the stars, with relevant differences between each of them that might alter the answer.

It is beyond the scope of this article to study whether each of the many single parts of space is an economic or legal commons, nor even each category of parts of space. Instead, Sections 3 and 5 examine select categories of parts of space to find if they are economic or legal commons in order to demonstrate the process of analysis this article advocates for.

2.3. Differentiating resource systems from resource units

Another important distinction is that between resource systems and the flow of resource units from the resource system [19,20,22]. The resource system can be a lake, and the flow would then be the fish in the lake. There can be more than one type of benefits from one resource system. The lake has fish but also water for drinking or irrigation. There can be different—and in a way "competing"—resource units, such as trees that bear fruits which can be picked, but alternatively, the trees can be chopped for use of the timber. The governance of resources needs to address the use of both the resource system and resource units. Rules must be in place to determine and perhaps limit the access to the system. Other rules must be in place to determine and perhaps limit the right to harvest the resource units to ensure sustainable use of the resource system and its flow of benefits [19].

The aforementioned distinction is important because the resource system and resource units do not necessarily have the same governing regime [19]. The contrary is more likely: Given the distinction and difference between the resource system and resource units and between the resource units themselves, there are likely to be several different governing regimes. One parcel of rights may be allocated with regard to the resource system and another—and probably different—parcels of rights may be allocated with regard to each resource unit. Furthermore, the different parcels of rights are likely to be granted to different actors. Continuing with the example of the lake, one set of rights may be allocated to the public which includes recreational access to the lake; another set of rights may be allocated to fishermen which includes fishing rights; and another set of rights may be allocated to nearby villages which includes rights to extract water for irrigation; yet another set of rights may be allocated to nearby towns, or the entire province, to extract water for drinking. Each set of rights will have distinct—and different—grantees, rights, and limitations.

3. Parts of space as economic "commons"

Economics as a discipline focuses on resources and their use. The classic dichotomy of Private Goods v. Public Goods, made by Nobel Laureate Samuelson (Economic Sciences, 1970), fits the classic institutional dichotomist view that markets are optimal for handling private goods but for the public goods we need a central government. The 2009 Nobel Laureate in Economic Sciences Elinor Ostrom added two types of goods: common-pool resources (CPRs) and Toll Goods. This section defines economic "commons", presents the four types of goods/resources (private goods, public goods, CPRs, and toll goods), and then determines whether parts of space—planets, minerals waiting to be harvested, void space, and orbits—are economic commons or another type of a resource.

3.1. Commons" and "common-pool resources" defined

The two terms "commons" and "common-pool resources" share the word "common" but have different definitions.

"Commons" are resources used by more than one actor. Examples often used in the literature are fish stocks, pastures, woods, and water (for drinking or irrigation). As Hess and Ostrom noted "Commons is a general term that refers to a resource shared by a group of people. In a commons, the resource can be small and serve a tiny group (the family refrigerator), it can be community level (sidewalks, playgrounds, libraries, and so on), or it can extend to international and global levels (deep seas, the atmosphere, the Internet, and scientific knowledge). The commons can be well bounded (a community park or library); transboundary (the Danube River, migrating wildlife, the Internet); or without clear boundaries (knowledge, the ozone layer)" [24].

A CPR is one of four types of goods/resources. It is a resource which has two features: (i) one person's use of the resource subtracts from the potential use of other persons and (ii) there is difficulty, physically or legally, to prevent actors from using the resource [19].

A resource or goods have various features, and two of them are relevant to their classification: (i) subtractability of use and (ii) the possibility of excluding potential beneficiaries. The first asks whether the use of the resource by one person subtracts from the use thereof by another person. In other words, will such use by one actor diminish or even nullify the potential benefit of future users. A chocolate bar is characterized by a high degree of subtractability: If one person eats the chocolate bar, others can no longer eat it. For this reason, the feature of subtractability is known in economics also as 'rivalry' as there is rivalry between the various potential beneficiaries from the bar. Land, whether used for agriculture or housing, is another example of high subtractability or rivalry. In contrast, when one person enjoys the peace and security as well as street lighting that the State provides, it does not subtract or diminish from the peace and security and street lighting that others can enjoy. These goods are characterized by low subtractability or nonrivalry.

The second feature, excludability, asks whether it is significantly difficult, physically or legally, or very costly, to exclude a potential beneficiary. It is relatively easy to exclude unauthorized persons from eating a chocolate bar or using a certain house. However, it is harder to prevent unauthorized entry to a vast forest and it is very difficult to prevent a certain person from enjoying the peace and security and street lighting provided by the State. It is likewise legally difficult to prevent an actor from using the open seas.

These two features of subtractability and excludability provide the four categories of resources or goods, as presented in Table 1 below:

A chocolate bar and apartment are private goods as there is rivalry in their consumption and it is easy to exclude potential beneficiaries from using them. A theater is a toll good—it is easy to exclude potential beneficiaries from entering it, but there is little rivalry: one person watching the play does not prevent others from watching the same play and having the same benefit, although there is capacity limit according to the available number of seats in the theater. A large groundwater basin is a CPR as one person's use of the water diminishes the potential benefit of other users, yet it is

Table 1
Types of goods/resources.

		Subtractability of use	
		High	Low
Difficulty of excluding potential beneficiaries	High	Common-pool resources: groundwater basins, lakes, irrigation systems, fisheries, forests, etc.	Public goods: peace and security of a community, national defense, knowledge, fire protection, weather forecasts, etc.
	Low	Private goods: food, clothing, automobiles, etc.	Toll goods: theaters, private clubs, and daycare centers

Source: [25].

difficult, physically or legally, from excluding potential beneficiaries. Street lights are a public good—one person's use does not diminish the potential benefit to others and it is difficult to prevent potential beneficiaries from using it.

Of interest to us are the CPRs as this article focuses on the "commons" feature of outer space and its resources. Nevertheless, we should bear in mind that classification of real-world cases to CPRs or public goods is not trivial. Both CPRs and public goods share the feature of nonexcludability, and it is the subtractability or rivalry that distinguishes between them. Some scholars suggest that there are very few real-world examples of "pure" public good with no rivalry [26,27], and others even treat both types the same.[3] Indeed, some physical resources may be classified as a CPR regarding one aspect of their provision or use and as a public good with regard to another as the case of a groundwater basin demonstrates [26]. Clearly, there is rivalry in consumption as one person's use of the water leaves less for the others, and it is therefore a CPR. On the other hand and at the same time, protection of the basin from salt water intrusion or pollution is a public good, as such protection is provided to all or none, and it cannot be provided only to some users. For this reason, it is suggested that the classification to CPR or public good should be made with regard to aspects of a resource rather than to its entirety.

3.2. Are parts of space economic "commons" or CPRs?

This section briefly examines select parts of space to find out if they are commons and/or CPRs according to the aforementioned definitions, demonstrating the process of analysis this article advocates for. As this section shows, not all parts of space are commons or CPRs.

3.2.1. Commons

Celestial bodies, orbits, and void space are resources used (or potentially used) by multiple users and therefore are economic commons. Those artificial objects in space that have multiple users, such as the ISS, are also economic commons, regardless of who owns them (but not necessarily CPRs, as the next paragraph demonstrates). Those artificial objects with a single user, e.g. a satellite belonging to and serving a single state, are not economic commons.

3.2.2. CPR

Article 1 of the OST provides that "…Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States…". It is therefore legally difficult to exclude potential users. The question remains regarding the subtractability feature of the various parts of space. Some orbits are congested and the use thereof by one actor subtracts from the use of other actors, whereas other orbits might be rather deserted with low subtractability. Void space probably features low subtractability; the moon, asteroids, and minerals seem to have the subtractability feature. Those parts of space that do not feature subtractability, for example, a deserted orbit or void space, are not CPRs. Those parts of space featuring subtractability, such as the geostationary orbit and the moon, are CPRs. The ISS features subtractability, but exclusion is easy, so it is not a CPR. Being a CPR has a meaning in terms of the economically efficient governance regime over the resource, as presented in Section 6.

[3] As reviewed in Jose Apesteguia and Frank P. Maier-Rigaud, The Role of Rivalry: Public Goods versus Common-Pool Resources, The Journal of Conflict Resolution, Vol. 50, No. 5 (2006), 646–663.

4. OST Article II, global commons and international law of property

4.1. Property rights under domestic and international law

Property rights are the product of society, and in modern times, they are granted or recognized by the State, in each State according to its domestic laws. There are also rules in private international law regarding recognition of property rights granted/recognized by other States. The picture is more complex with regard to domains and resources outside the territory of any and all States, e.g. the high seas, outer space, and Antarctica,[4] to which many refer as "global commons".

Sprankling [28] asserts that it is time to develop an "international law of property" and that principles and doctrines of international property law have already emerged, and one of these doctrines is that of the global commons. However, the common conception is still that property rights arise under the domestic law of a particular state. Accordingly, the theoretical analysis of property rights in the following Section 5 is based on how property rights have been recognized at the national level. Nevertheless, the theoretical part is relevant also to potential property rights if such will be granted/recognized by a supranational entity or instrument, including the basic principles of the sticks of rights and the type and identity of the holder of rights. If the UN or an international treaty starts granting/recognizing property rights, these will likely follow the same principles, only with a different granting/recognizing authority. Until then, international law can permit, or not prohibit, States' granting/recognizing property rights.

As outer space is one of the traditional examples of global commons, the rest of this section analyzes the notion of global commons and its contribution—or lack thereof—to our understanding of global commons applicable property rights regime.

4.2. OST Article II and the notion of global commons

OST Article II precludes national sovereignty in outer space, and thereby—so is the common view—renders outer space to be global commons. But, what does it mean for a domain to be global commons and does it or Article II provide a property rights regime?

The notion of global commons is said to be the modern incarnation of Hugo Grotius' principle of *mare liberum* [29],[5] freedom of the seas, which rules out national sovereignty and ensures freedom of access to, and movement within the domain. Grutius' view was accepted, whereas opposing views by his British [30] and Portuguese [31] contemporaries were rejected.

The term "global commons" has no formal definition, and it does not appear as such in international treaties. The available definitions by the UN Division of Environmental Law and Conventions [32] and the OECD [33], as well as by scholars such as Buck [34], Vogler [35], and Schrijver [36], have a single characteristic—global commons are outside any and all national jurisdictions. Buck also adds a second characteristic which is free access to the domain. Other scholars provide definitions limited to the purposes of their current article [37,38]. There are three or four traditionally recognized global commons—the high seas, outer space, and Antarctica, and some add the atmosphere. The radio spectrum, the use of

[4] While Article IV of the Antarctic Treaty of 1959 prohibits claiming sovereignty over any part of Antarctica, it does not nullify preexisting claims, nor does it confirm them.

[5] In fact, the Romans had declared that the seas were communes omnium naturali jure (common to all humankind) in the 2nd century CE, following the writings of the Roman jurist Marcianus, as was later also recorded in Roman emperor Justinian I's the Digest of Justinian.

which is regulated by the ITU Constitution, might be yet another one. If we follow these definitions, the content of the notion of global common is very limited: It is simply a domain which no State may validly purport to subject to its sovereignty. At most, one can add the free access to the domain and even that is doubtful as it is not guaranteed for all traditional global commons. OST Article I guarantees free access and movement and so does UNCLOS Article 87, whereas the Antarctic Treaty provides merely freedom of scientific investigation (Article II).

There is a recent inflation in the use of the term "global commons" as newer, sometimes disputed, uses of the notion purport to apply it also to cyberspace [39], the internet [40], crop genetic resources [41], the climate [42], human genome, immaterial cultural heritage, and even biodiversity, tropical rain forests, science, education, information, and peace [43]. The alleged new global commons do not even share the single characteristic, i.e. that no State may validly purport to subject the domain to its sovereignty. The rainforests are – legitimately – under national sovereignty. Moreover, for others, like education, biodiversity and peace, sovereignty is not the issue.

The notion of global commons is used to describe domains that significantly differ in character and legal regime which renders the scope and content of the notion unclear. The four traditional global commons are different from each other and so is their legal regime. Moreover, the many new global commons bring even greater diversity and therefore uncertainty about the meaning of the notion and what is derived from designating a domain as global commons.

The gradual increase of importance of various domains labeled as global commons, and mainly their resources, has led to significant discourse on the topic, as may be evidenced by the many conferences worldwide dedicated to global commons. The inflation in designation of new "global commons" might reflect a perspective that they are of global interest and that there should be international cooperation in the establishment of the regimes on these domains. There is even arguably an emerging "global commons law" [44]. Yet, there is a long way to go before a clear and meaningful content is poured into the notion.

4.3. Property-right regimes and the common heritage of mankind

An important question is whether the domains labeled as global commons have a distinct property right regime—e.g. open access or common property—and the short answer is no. Even if we limit the scope of our inquiry to the three most agreed global commons—outer space, the high seas, and Antarctica–we see that the applicable rules vary between these domains and *even within a single domain*.

Some of the economic benefits from the high seas are under an open-access regime: Article 87 provides freedom of use of the sea routes and air routes above the high seas; the freedom to lay cables and pipelines; the freedom to construct artificial islands and other installations; and the freedom of fishing.[6] All these require no permission, although they meet the requirement of the treaty. This is an open access regime (see section 5.6 below for the meaning of open access). However, the deep seabed has a different regime. Article 136 of UNCLOS declared the seabed and ocean floor and subsoil thereof and their natural resources to be the "common heritage of mankind" (CHM)[7] [45] and their mining requires permission from the International Seabed Authority in what seems to be a common property regime (see section 5.6 below for the meaning of common property). The drafters of UNCLOS chose to add a designation of CHM to resources to which a common property is to be applied.

The OST, while banning national sovereignty in Article II, also explicitly allows the exploitation of outer space (Article I).[8] Under the ITU regulations, slots in the geostationary orbit are allocated by the ITU, in what seems again to be a common property regime. However, there is no similar regime to other resources in outer space. Significantly, the Moon Agreement [46] took a similar path to that of UNCLOS by declaring in Article 11(1) all celestial bodies and their natural resources to be CHM—this is in addition to the ban on national appropriation in Article 11(2). In both cases, it seems that the drafters of UNCLOS and the Moon Agreement were in the opinion that barring national sovereignty (or designating a domain to be global commons) is not enough to provide any property rights regime, or at least not a regime of common property. Indeed, Article 11 of the Moon Agreement is perceived as the main reason most states have chosen not to ratify the Moon Agreement as they may not wish to introduce the CHM principle which adds a layer of rules and limitation on top of those included in the notion of global commons.

The Antarctic, to which even freedom of access is not guaranteed, has a regime regarding mining that is totally different from that of the OST and UNCLOS and also different from the regime on other economic benefits from the Antarctic. The 1988 Convention on the Regulation of Antarctic Mineral Resource Activities (CRAMRA), which allowed mining, failed and was replaced by the 1991 Protocol on Environmental Protection to the Antarctic which bans mining. This ban can be renegotiated after 50 years (Article 25(2)). It should be noted that the CRAMRA that allowed mining did not apply the CHM principle to the resources of the Antarctic, and the principle is not mentioned in any of the instruments constituting the Antarctic Treaty System. However, fishing in the Southern Ocean (south of the Antarctic Convergence) is allowed[9] and so is tourism[10].

Moreover, there is another distinct difference between the various treaties as only one treaty explicitly mentions property rights. The provisions in UNCLOS Part XI [47] and in the 1991 Protocol on Environmental Protection to the Antarctic, which regulate mining, merely regulate the *activity* of resource exploitation ("activity" is the term used in both instruments). The Moon Agreement took a different course: It specifically provides that no part of celestial bodies and their resources can become the property of any state, entity, or person (Article 11(3)). Comparing the aforementioned variance, one might even deny that the UNCLOS and Antarctic Treaty System provide *any* property right regime, and for that matter also the OST. In any case, even the most established regime—that of the deep seabed—does not render national regulation redundant. A permission from the International Seabed Authority to exploit the seabed permits, inter alia, the alienation of mined resources. Thereafter, States may grant/recognize property rights in the mined resources. Indeed, several states adopted national laws of mining of the seabed, including the United States, Russia, the UK and France [48].

In view of this, designating a domain as global commons does not enlighten us as to the applicable property rights regime, as such

[6] The freedom of fishing in the high seas is also provided and elaborated in Part VII Section 2 of UNCLOS.

[7] On the CHM principle see, for example, Baslar [43].

[8] See also de Man (2016) (cited in note 1).

[9] Under the Convention on the Conservation of Antarctic Marine Living Resources.

[10] Tourism is explicitly mentioned in the 1991 Protocol on Environmental Protection to the Antarctic Treaty. In addition, several Antarctic Treaty Consultative Meetings discussed tourism and the Treaty Parties adopted guidelines on tourism and guidelines for visitors to the Antarctic, e.g. Resolution 3 (1995), Resolution 3 (1997) and Resolution 3 (2011).

regimes, if at all established, significantly vary in and between the various domains commonly referred to as global commons.

4.4. Back to property rights theory

OST Article II that bars national sovereignty is not enough to provide any specific property rights regime, let alone a regime of common property. Global commons is a slippery term that does not imply the property right regimes in the domains and resources it presumably describes. Asserting that outer space is "global commons" does little to promote our understanding of the applicable legal regime as the term is not official and is of limited or unclear content and scope. Therefore, the recent declaration by the Executive Secretary of the US National Space Council that outer space is not global commons [49] neither hinders our understanding of the applicable legal regime nor undermines conventions or poses a barrier to the development of the governance of space resources. The declaration carries significant importance in exposing the underlying US policy towards space resources, if it meant to suggest that outer space is not (global) common property or legal (global) commons, but rather open access (see section 5.6 for definitions).

There is a steady increase in the importance of the traditional global commons, an inflation of new global commons, and an increase in the discourse on the topic. This may lead to the emergence of a distinct law of global commons, as some believe and aspire, which makes it critical to get the basic concepts right, so this body of law—should it emerge—is built on sound foundations. The next section therefore goes on to review the general theory of property rights, including what is "legal commons", which should be applied in the interpretation of the relevant provisions of the OST and other relevant instruments.

5. Parts of space as legal "commons"

The economic analysis focuses on the resource, whereas the legal analysis should focus on the rights *vis-à-vis* the resource or the legal regimes that governs it, i.e. property rights. If an economic commons is a resource *used* by multiple actors, a "legal commons" is a resource or right jointly *owned* by multiple actors. The following sections dismantle property rights to their basics, and section 5.6 then elaborates on what is "legal commons".

5.1. The artificial creation of "property rights"

Property rights do not exist in nature, nor could they exist for Robinson Crusoe before the appearance of Friday [50]. They are the product of society (which is also an economic system) and its rules. Property rights are granted or at least recognized by the society, through rules, and recognized and respected by institutions and the other members of the society. The notion of "property rights" has occupied the attention of generations of thinkers. The understanding of property and the distribution of property have changed considerably through time and have adapted to the changes of the socioeconomic conditions. The understanding and distribution of property were always influenced by and themselves influencing the utilization of natural resources and the (relative) status of various members of a society.

'Commons' is an economic term used in the legal literature in inconsistent ways that often deviate from its economic definition. Similarly, 'property rights' is a legal term used by economists in inconsistent ways that often deviate from its legal definition. The notion of property rights is central to the language of economics and the divergence of some of the economic literature, including by leading economists, from conventional legal understandings of property rights creates "interdisciplinary confusion and bias economic analyses" [51,52]. The deviation from the legal definition also makes cross-disciplinary dialog difficult [26]. This section presents the modern legal conceptualization of property rights and applies it to the context of commons and space resources.

5.2. The modern theory of "property" and the "rights" in property rights

Property rights have a long history, yet there is no common definition thereof, but rather their definition has changed over time and space. The classic—and perhaps still common in popular culture—notion of property right as an all-encompassing power was expressed in Blackstone's Commentaries on the Laws of England (1765):

> …the right of property… that sole and despotic dominion which one man claims and exercises over the external things of the world, in total exclusion of the right of any other individual in the universe [53].

Similarly, the French Civil Code of 1840 provided that "Ownership is the right to enjoy and dispose of things in the most absolute manner, provided they are not used in a way prohibited by statutes or regulations" [54].

Modern property right theory has a more complex view of property rights. For much of the twentieth century, legal academics conceptualized property as a bundle of rights [55–57]. According to this conceptualization, property rights give certain members of the society the right to access a stream of benefits (also referred to as "sticks") from given resources. The "sticks" include the right to access, use, exclude, sell, lease, mortgage, donate, subdivide, etc. The "sticks" regarding a specific resource may be held together by one person or be separated and held by several holders [55]. A rented apartment is a simple example for different sticks held by different persons: The "owner" has the right to sell, lease, mortgage, etc. the apartment; the renter has the right to access and use the apartment, rights she is paying for and are now denied from the owner for the duration of the contract.

Furthermore, property rights are not all encompassing as in the Blackstonian conceptualization. The fact that a person owns a piece of land does not make her "queen of the castle". She may have to pay taxes to the government for this land, need a permit to build her castle and be restricted in the square foot she can build and will have to follow numerous other applicable laws when using it. The airspace above her piece of land is not hers, but the state's and in many countries also mineral resources in the ground, such as oil. Property rights are further often partially shared with others, as in the case of a condominium in which the various apartments' owners share public spaces, such as the elevator, with the other apartment owners.

The traditional concept of property rights viewed them as relationships between individuals and things, whereas the bundle of rights theory sees property rights as manifesting in relationships between the members of a society. Under this modern view, property rights establish relationships among the members of a society and determine relative powers of the members *vis-à-vis* resources and each other [55].

The bundle of rights theory indeed well explains many facets of property. However, since the 1990s, the "bundle of rights" theory has been provocatively challenged [58], notably by Penner [57,59], Merrill and Smith [60–71]. The challenges were answered by eminent scholars, e.g. Epstein [72] and Munzer [73], with others such as Ellickson [74] taking a middle ground. There is even a suggestion to adopt a new concept of property as the "law of things" [81]. Yet, the "bundle of rights" theory is still the leading explanation of the essence of property and is used herein.

5.3. The rights ("sticks") relevant to CPRs and space

If property is a bundle of rights, then some of the sticks in the bundle are relevant to the economic discussion of CPRs. Schlager, whose research focuses on institutional analysis of the governance of the commons, and Ostrom pointed to five rights that are most relevant for the use of common-pool resources [52][11]:

> Access: The right to enter a defined physical area and enjoy nonsubtractive benefits (for example, hike, canoe, sit in the sun).
> Withdrawal: The right to obtain resource units or products of a resource system (for example, catch fish, divert water).
> Management: The right to regulate internal use patterns and transform the resource by making improvements.
> Exclusion: The right to determine who will have access rights and withdrawal rights and how those rights may be transferred.
> Alienation: The right to sell or lease management and exclusion rights.

This classification is especially helpful in discussing property rights in/to space in general and in the context of space mining in particular. I limit the analysis to the meaning of the 1967 OST. Article I of the OST provides

> The *exploration and use* of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and *shall be the province of all mankind.*
>
> *Outer space*, including the moon and other celestial bodies, *shall be free for exploration and use by all States* without discrimination of any kind, on a basis of equality and in accordance with international law, and *there shall be free access to all areas of celestial bodies.*
>
> There shall be *freedom of scientific investigation in outer space*, including the moon and other celestial bodies, and States shall facilitate and encourage international cooperation in such investigation. [emphasis added]

In terms of the aforementioned five rights, it seems straightforward that Article I grants all states the first right, that of "access"; it is unclear whether the right of "withdrawal" is also granted, i.e. whether withdrawal falls under "use" of space that is free to all states. The rights of management, exclusion, and alienation are given neither to any single state nor to an intergovernmental organization, and therefore they fall by default in the hands of all states collectively or humankind.

5.4. Types of holders of property rights and spacefaring nations' rights

An alternative way to talk about the rights that property rights entail is to make a classification by types of holders of (bundle) of rights, rather than a classification of the rights in the bundle. Ostrom and Schlager [52] identified five types of property rights holders, as shown in Table 2 below:

A person hiking in a national park is an "authorized entrant", whereas a fisherman with a fishing license in a lake is an "authorized user". Further up the line, a "claimant" can establish rules and restrictions on the access and withdrawal (e.g. "opening hours", purpose of use, identity and quantity of resource units harvested), which is the right of management (a collective-choice right). At the next level, a "proprietor" has, in addition to the rights of a claimant, the right to determine who may access and harvest from a resource. Finally, "owners" possess, in addition to all the aforementioned rights, the right of alienation, i.e. the right to transfer (e.g. sell, lease) a resource (or the management and exclusion rights to it). It is important to note that individuals or collectives may hold any of the various sets of property rights, which means that a collective can be the "owner" of a certain resource. Most of the property systems that are called "common-property" regimes involve participants who are proprietors [19].

Table 2
Bundles of rights associated with positions.

	Owner	Proprietor	Claimant	Authorized user	Authorized entrant
Access	X	X	X	X	X
Withdrawal	X	X	X	X	
Management	X	X	X		
Exclusion	X	X			
Alienation	X				

Source: [75].

Article I of the OST makes all states at least an "authorized entrant" as there is freedom of access, exploration, and scientific investigation. It can also be argued that Article I makes states more powerful holders, "authorized users", as the freedom extends to "exploration and use". It may, however, be asserted that the term "use", in Article I of the OST, does not include withdrawal, i.e. that the term "use" in the legal text of the OST carries a somewhat different meaning or definition than the term "use" in the previously given definitions, taken from economic literature.

It is important to note, in line with the distinction between the type of resource and the property rights over it (the type of legal regime applicable to it), that any kind of property, including a CPR, can have various types of "holders" (i.e. owner/proprietor/claimant/authorized user/or authorized entrant).

5.5. Identity of holders of property rights and common property in space

There are different "sticks" representing rights to property; some of them, also presented previously, are relevant to CPRs. There are several types of holders of property rights according to the parcel of sticks they hold. The identity of the holders is another question all together, separate from the type of holder (Table 2). The identity of the holders (holder understood as the owner/proprietor/claimant/authorized user/or authorized entrant) can vary, i.e. it can be an individual, corporation, government, or communal group [76]. The "claimant" can be a person, government, or collective. If the holder is a collective, then we can say it is – indirectly – "common property", i.e. the bundle of rights is jointly held (or indirectly in common) by a limited group of actors [77].

5.6. The number of holders of property rights, legal commons, and open access

There are three main options for the number of holders of property rights, zero, one, and multiple (two or more), and they correspond to open access, private property, and common property.

Private property means that there is a single owner of the resource or right in question. *Common property* means that there are two or more owners who jointly own the resource or right in question. The coowners can comprise of anyone who can legally own property, e.g. individuals, corporations, the state, or a mix

[11] Hess and Ostrom note that with new commons, such as the Internet, the bundle may include other types of rights. Hess and Ostrom found that electronic information resources often have more than five types of rights, and they pointed to seven major types of rights: Access; Contribution; Extraction; Removal; Management/Participation; Exclusion; and, Alienation [19,24].

thereof. When talking about commons as a legal regime, or legal commons, I refer to common property. *Legal commons therefore means that a certain resource or right has more than one owner.* If there is a single owner but this owner is the State or a collective, we might view it as a case of private property, as the State or collective represents the entire public/members of the collective and holds ownership in a sort of fiduciary whereas the public/members of the collective, or all the many individuals which comprise the public/collective, are the ultimate owners of the resource. *Open access* means that the resource or right in question has no owner. The resource is open to the public so that anyone can use it and its economic benefits without the need for permission. In this case, the number of owners is zero, whereas there is a limit neither on the number or identity of users nor on the extent of their exploitation of the resource.

Admittedly, the open-access regime is confusing because its title—open access—insinuates reference to use rather than ownership. Let us therefore deconstruct the open-access regime. The trait of a resource being open to all may derive from four cases of identity or number of owners: (i) under domestic or international law no one can validly establish ownership over it. The number of owners is and will remain zero; (ii) ownership may be validly established, but no one has yet done so. The number of owners is zero but may change; (iii) the resource has an owner or owners but the owner(s) is/are keeping it open to all, for example, a lakeshore owned by the State or jointly by the State and the municipality which maintain the lakeshore open to all; and (iv) all relevant actors jointly own the resource and therefore all have access to it. For example, if all people in the village/world jointly own a lakeshore, it is open for all of them to use.

The first two cases are open-access regimes. The third case is either private or common property, and the open access is not guaranteed by the lack of ownership but rather by the policy of the owner. The fourth case is of common property, and it is the ownership-by-all that guarantees open access to all, as all are owners.

The first two cases are open access, whereas the third and fourth cases are not, even though the resource is open to the public, and there are practical aspects to this difference. In the first two cases, no one can limit the use of the lakeshore—as there is no owner—whereas, in the third and fourth cases, there are owners and they can regulate the use thereof. For example, while the State which owns the lakeshore declares it to be open for all, it stipulates opening hours, dress code, no-smoking policy, etc. Similarly, in the fourth case, all the owners together, or by a representative managing board, can regulate and limit the use of the lakeshore. Indeed, open access is characterized by the lack of constraints on both the number of users and the amount that each user may extract [78], hence the risk of over-harvesting and other unsustainable use, or, in Hardin's famous phrase, the "tragedy of the commons" [79]. Indeed, when Hardin coined the phrase "tragedy of the commons", he was actually talking about *open access*, not *common property* [19]. The "pasture open to all" he discussed was not and could not be regulated as there was no owner.

I do not use the Latin terms which are often mentioned in this context (e.g. *res nullious*, *res communis*) on purpose as I find that using them adds to the discourse a set of concepts with their particulars which may complicate, rather than simplify and clarify, the discourse. For example, terra nullious has a certain meaning in international law scholarship that is narrower, or at least different, from open access which I discussed previously and which many associate with *res nullious*. It is not the aim of this article to discuss the correlation between *terra nullious*, *res nullious*, and open access. I also agree with Hertzfeld, Weeden and Johnson [18] regarding the pitfalls of using Latin terms in the discourse on space resources.

Common property, it should be emphasized, is by no means limited to socialistic economies, but rather is prevalent even in the most capitalist economies. "Private goods", in the meaning presented in Section 3.1, is often held by a group of owners and is thus "common property"; this includes the shared spaces in a condominium (e.g. the elevators) and even the hallmark of capitalism, the corporation, is common property, if it has more than one shareholders. Another symbol of capitalism—the private equity investment funds—is in itself common property. These investment funds are typically limited partnerships for collective investments in various securities, mostly equity. The limited partnership agreement (LPA) sets forth the terms according to which the partnership is governed and operated.

The 1967 OST grants rights to "mankind", when providing that "[t]he exploration and use of outer space … shall be the province of all mankind". Mankind, or humankind, is not a clear entity with organs operating in its name. The OST also grants rights to all states, when it provides that "Outer space … shall be free for exploration and use by all States".

The aforementioned definitions and differentiations allow us to examine whether the 1967 OST establishes common property in space. According to the OST, certain "sticks", e.g. the right to access, are given to all states, *separately*. Therefore, the identity of the holder is not a group, and it is not "common property". Other rights, e.g. the rights of management and exclusion, are not held by any single state and thus, by default, are in the collective hands of all states as collective-choice decisions. These rights are therefore "common property" of all states. In other words, private ownership coexists side by side with common property. Such a cohabitation of the private and commons is not rare [19]. It is doubtful whether a right of alienation exists *vis-à-vis* natural parts of space.

If the picture portrayed so far seems complex, it is precisely because it is so. To avoid confusion and analytical errors, it is necessary to be aware and pay attention to the distinctions between the economic and legal; between the resource and property rights over it; between the resource system and resource units; and between the type of resource, type of holder, and identity of the holder. It is important to consistently follow the definitions and proper uses of the notions of commons, CPRs, and property rights.

The brief suggestion of possible answers regarding the "commons" feature of parts of space demonstrates the complexity of the question, or questions to be exact, and the need for a well-structured study of the issue in order to arrive to persuasive conclusions.

6. Connecting the economic and the legal: the appropriate governance of space resources

In Section 3.1, I have presented the four different types of resources according to economic analysis (see Table 1). The different types of resources have different types of suitable and efficient governance and property rights regimes. Therefore, identifying the type of resource each part of space belongs to is critical for choosing the proper management regime for it. An improper regime will necessarily lead to a waste of resources or unsustainable use thereof.

Resources that are "private goods" in the economic meaning are normally better governed by a legal regime of private property. This is well established and recognized also by proponents of common management regimes for certain resources [19]. Other types of resources have different types of efficient governance regimes. In particular, as Ostrom demonstrated [23,25], resources that are (economic) CRPs are better managed by the users by way of collective action. For these types of resources, even if other types of management are feasible, e.g. government management or private

property, users' management is the proper regime to select because it is more efficient than the alternatives.[12]

There is therefore connection between the type of resource in the economic meaning and the efficient governance thereof, governance that may be established or described in terms of a legal regime of property. Hence, there is a connection between the economic and the legal.

Another thing to remember when analyzing property right regimes is that property rights rules have distributive effects, i.e. property rights regimes affect the distribution of gains and losses between the various actors. Moreover, when there is a significant variety of technological advancement between the different actors, the distributive effects are even more meaningful [19,80], and the exploitation of outer space is depended on a high level of technological advancement. Many of the UN General Assembly resolutions regarding the exploitation of outer space have repeatedly expressed concern regarding the distribution of the benefits from this exploration. For example, Article I of the OST provides 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…". Keeping this promise requires paying attention also to the distributive effects of each possible property rights regime.

7. Conclusion

The discourse on the commons feature of space or whether or not space is commons should be rephrased and relaunched. To begin with, the discourse must differentiate between economic commons and legal commons, i.e. between the resource itself (and its economic features) and the legal regime applied to it. In doing so, we must remember that commons in one meaning does not mean commons in the second meaning and that an economic commons can be private property in the legal sense of the term.

The second step is to rephrase the questions as it should not refer to space as a whole. Instead, the analysis must be undertaken separately for each part of space or at least categories of parts of space, e.g. planets, starts, moons, asteroids, resource units (e.g. helium, platinum, water); void space; artificial objects as satellites and the ISS. Even the use of categories needs care because, for example, the category of "earth orbits" may include orbits that are CPRs and orbits that are not. Another important distinction is between resource systems and resource units because the resource units flowing from a resource can have a different legal regime than the resource system itself.

As this paper demonstrated, the notion of 'global commons', often applied to outer space, is of limited or unclear meaning and it does not imply the property rights regimes in the domains and resources it presumably describes, including outer space. Therefore, the analysis should follow the following lines: after having identified a specific part of space or category of parts of space and having established which kind of resource it is, according to the economic definitions, we can associate the efficient governance regime to it, according to the economic literature, and move forward to suggest the appropriate legal regime. Alternatively, or simultaneously, after having identified a certain part of space or category of parts of space, we can ask what kind of legal regime do the space treaties provide with regards to it, if any. Only if the discourse on space resources will follow the proper definitions and distinctions presented herein, will we be able to both devise sound legal interpretation and craft policy based on the accumulated knowledge on the proper governance of the commons.

The initial economic analysis herein shows that space is made of several parts, most of which—but not all—are economic commons, whereas some are CPRs. Celestial bodies—including asteroids and their minerals—and congested orbits, are all CPRs. CPRs, as Ostrom has shown, are best managed by their users.

The initial legal analysis showed that some legal rights, e.g. access, are held by each and every state, whereas others, e.g. management, exclusion (but not alienation), are held collectively by all states or humankind. In other words, the right of management is common property of all states or of humankind. It is not clear whether the right of withdrawal is also given to each and every state, as part of the freedom of use granted by the OST. Each state is therefore at least an authorized entrant and possibly, if "use" includes withdrawal, an authorized user.

This article purports to structure the discourse on the commons feature of space resources and their proper governance. Conducting the discourse along these lines will enable application of and contribution to the cutting-edge literature in both the fields of economic sciences and legal theory and conducting a cross-disciplinary discourse on the issue.

[12] In contrast, Hertzfeld et al. suggest that '[t]he particular usefulness of Ostrom's approach is that it is developed for situations where neither of the two traditional solutions to the tragedy of the commons, complete privatization or a Leviathan to impose rule of law, are feasible' [18].

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