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SYMPOSIUM ON THE GLOBAL GOVERNANCE IMPLICATIONS OF BLOCKCHAIN

BLOCKCHAIN IN OUTER SPACE

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Blockchain technology has spurred the emergence of powerful narratives to promote new ways of governing outer space. The list of proposed uses for blockchain applications in outer space is endless—from property registries for asteroid mining, to supply chain management systems, or interplanetary cryptocurrencies for the space economy—along with Elon Musk claiming that "SpaceX is going to put a literal Dogecoin on the literal moon."[1] Yet, thus far, none of these projects have gone beyond simple declarations or white papers, mostly due to the inherent limitations on the effective enforcement of blockchain-based rules outside of their own technical framework. In this essay, we argue that blockchain technology is relevant for outer space because it fosters novel narratives[2] advancing possible futures characterized by new modes of governance. The strongest and most prominent of these narratives is the crypto-libertarian one, which draws heavily on the absence of a state, the sanctity of property, and the primacy of private ordering through decentralized markets. But there are other narratives proposed by relevant actors in the blockchain space that are dedicated to other modes of governance.[3] By focusing on alternative narratives for blockchain technology, we illustrate how the possible applications of blockchain technology in outer space may extend beyond the current libertarian dreams, to support a more commons-based approach to outer space governance.

International Legal Framework of Outer Space Governance and the Commercial Space Industry

Outer space governance was established through a series of international treaties, enacted during the Cold War period. The Outer Space Treaty of 1967 (OST) is the most significant piece of legislation in this regard. It establishes an international legal framework for outer space, intended to preserve outer space as a *global commons*—i.e.,

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[1] Elon Musk (@elonmusk), Twitter (Apr. 1 2021, 6:25 a.m.).

[2] Narratives that are closely entangled with technological advances, such as the ones described here, have been called sociotechnical imaginaries by Sheila Jasanoff. *See* Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power 10 (Sheila Jasanoff & Sang-Hyun Kim eds., 2015). For understanding blockchain as a narrative technology, see also Andrea Leiter, *Life in Blocks: How Blockchain Technology Narrates the World*, *in* Research Handbook on Law and Literature (Peter Goodrich, Daniela Gandorfer & Cecilia Gebruers eds., forthcoming 2022); Wessel Reijers & Mark Coeckelbergh, *The Blockchain as a Narrative Technology: Investigating the Social Ontology and Normative Configurations of Cryptocurrencies*, 31 Philos. Technol. 103 (2018).

[3] *See The Trust Machine: The Technology Behind Bitcoin Could Transform How the Economy Works*, The Economist (Oct. 31, 2015); Primavera De Filippi, Morshed Mannan & Wessel Reijers, *Blockchain as a Confidence Machine: The Problem of Trust & Challenges of Governance*, 62 Tech. in Soc'y 101284 (2020).

a "province of [hu]man kind" that shall remain free for exploration by all states, and that should not be subject to national appropriation by any means (Article II).

At the time of drafting of these treaties, outer space exploration was primarily an affair of national governments, which was principally undertaken for geopolitical purposes. With the exception of a few private efforts, sovereign powers were the main source of investment for space exploration, and—while it was predicted that private actors would eventually engage in outer space activities—it was considered preferable that state actors remain responsible for outer space governance.

Today, however, space activities are increasingly dominated by private actors.[4] The global space economy grew from 200 billion USD in 2005 to 450 billion USD in 2021, with 80 percent of the revenue generated by private companies, mostly driven by U.S.-based entrepreneurs.[5] Corporations such as SpaceX, Blue Origin, and Virgin Galactic have already announced the dawn of the "commercial space age."[6] While the geopolitical underpinnings cannot be ignored, these companies are participating in the race for space exploration mostly for commercial reasons.[7]

As private entities, these companies are not *directly* subject to the provisions of these international treaties; yet, they are *indirectly* affected by them, to the extent that they are expected to respect the laws of the country in which they operate, which are subject to the treaties' provisions. As a result, it is generally understood that—just like national governments—private companies cannot claim sovereignty over any celestial body in outer spaces. Yet, the wording of the relevant treaties is sufficiently ambiguous as to allow for the commodification of outer space resources by private parties.[8] Indeed, if the OST framework for the governance of outer space was aimed at preventing national appropriation, it never excluded the possibility of extracting resources from outer space,[9] provided that the extraction is undertaken "for the benefit and in the interest of all humankind" (Article 1).[10]

Accordingly, in recent years, some countries—such as the United States,[11] Luxembourg,[12] the United Arab Emirates,[13] and Japan[14]—have enacted laws enabling private entities to claim ownership over the resources they extract from outer space, provided that this does not entail or presuppose claims of national sovereignty.[15] These countries are interpreting the provisions of the OST in such a way as to allow for the private appropriation of resources in outer space, despite the explicit prohibition of national appropriation of celestial bodies.[16] This interpretation is explicitly recognized in Section 10 of the Artemis Accords of October 2020, stipulating that

[4] Isabel Feichtner & Surabhi Ranganathan, *International Law and Economic Exploitation in the Global Commons: Introduction*, 30 Eur. J. Int'l L. 541, 543 (2019).

[5] Space Foundation, *Global Space Economy Nears $447B*, The Space Report Online.

[6] Matthew Weinzierl & Mehak Sarang, *The Commercial Space Age Is Here*, Harv. Bus. Rev. (2021).

[7] Gurbachan Singh Sachdeva, *Commercial Mining of Celestial Resources: Case Study of U.S. Space Laws*, 16 Astropolitics 202 (2018).

[8] Matthew Shaer, *The Asteroid Miner's Guide to the Galaxy*, For. Pol'y 44, 47 (Apr. 28, 2016).

[9] Matt Craven, *"Other Spaces": Constructing the Legal Architecture of a Cold War Commons and the Scientific-Technical Imaginary of Outer Space*, 30 Eur. J. Int'l L. 547, 548 (2019).

[10] Feichtner & Ranganathan, *supra* note 4, at 541.

[11] U.S. Commercial Space Launch Competitiveness Act (2015) (Space Act).

[12] Luxembourg's Space Resources Law. U.S. Commercial Space Launch Competitiveness Act (2015).

[13] The United Arab Emirates issued a comprehensive space law consisting of nine chapters and fifty-four articles that regulates, *inter alia*, the usage of space resources.

[14] Law Concerning the Promotion of Business Activities Related to the Exploration and Development of Space Resources (June 2021) (Japan) (in Japanese).

[15] Amanda M. Leon, *Mining for Meaning: An Examination of the Legality of Property Rights in Space Resources*, 104 Va. L. Rev. 497 (2018).

[16] Julie Michelle Klinger, Rare Earth Frontiers: From Terrestrial Subsoils to Lunar Landscapes 208 (2017).

"the extraction of space resources does not inherently constitute national appropriation under Article II of the Outer Space Treaty."[17]

This increase of commercial activity and its support in national legislation builds on the presumed distinction between the national appropriation of celestial bodies (through a claim of sovereignty) and the private appropriation of celestial resources (through private property claims). This distinction is grounded on the alleged separation of roles and jurisdictions between the state and the market,[18] mostly supported by liberal and libertarian visions of society.[19] Although these visions recognize the complementarity between the market and the state, they consider that resource allocation is generally best achieved through a decentralized market, only involving a minimal state[20] in charge of protecting private property rights.[21]

Blockchain Narratives for Outer Space

It is in this alleged separation between the state and the market that blockchain technology enters into play, bringing a new set of narratives for private ordering[22] based on the myth of an autonomous and decentralized market order.[23] In particular, blockchain narratives of transnationality (i.e., spanning across multiple jurisdictions)[24], alegality (i.e., existing beyond the purview of the law),[25] and self-sovereignty (i.e., operating independently of any sovereign authority)[26] can be regarded as relevant catalysts for some of the emerging practices of private ordering in outer space.

The decentralized character of blockchain technology facilitates coordination between multiple parties, with no centralized control. The transparency and tamper-resistance of the technology makes it possible for anyone with an Internet connection and a blockchain wallet to record information in a secure and immutable manner, providing a secure audit trail of *who has done what when*. Finally, the automation inherent in smart contract-based systems enables operations to be carried out automatically by the underlying blockchain network, without any third-party intervention.

While the legal validity and enforceability of these smart contract provisions ultimately depend on the laws of national jurisdictions, blockchain technology enables the creation of an alternative regime to traditional property

[17] Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes.

[18] Isabel Feichtner, *Mining for Humanity in the Deep Sea and Outer Space: The Role of Small States and International Law in the Extraterritorial Expansion of Extraction*, 32 Leiden J. Int'l L. 255, 265 (2019).

[19] Quinn Slobodian, Globalists: The End of Empire and the Birth of Neoliberalism (2018); Wilhelm Röpke, *Economic Order and International Law*, 86 Collect. Courses Hague Acad. Int'l Law 203, 244 (1954).

[20] The idea of a "minimal state" was advanced by Robert Nozick, Anarchy, State, and Utopia (1974) and ties back to the term "Nachtwaechterstaat" coined by Ferdinand Lasalle in a speech in 1862.

[21] Note that most accounts within and outside (neo-)liberal scholarship would reject a complete reduction of the role of the state and emphasize the importance of national laws for enabling the market. *See, e.g.*, João Rodrigues, *Where to Draw the Line Between the State and Markets? Institutionalist Elements in Hayek's Neoliberal Political Economy*, 46 J. Econ. Issues 1007, 1010 (2012).

[22] Dreamscapes of Modernity, *supra* note 3, at 10.

[23] Rodrigues, *supra* note 21.

[24] Melanie Swan, Blockchain: Blueprint for a New Economy (2015).

[25] Primavera De Filippi, Morshed Mannan & Wessel Reijers, *The Alegality of Blockchain Technology*, *in* Pol'y & Soc'y, special issue on *The Policy Dilemmas of Blockchain* (forthcoming 2021).

[26] Marcella Atzori, *Blockchain Technology and Decentralized Governance: Is the State Still Necessary?* (2015); Primavera de Filippi, *Citizenship in the Era of Blockchain-Based Virtual Nations*, *in* Debating Transformations of National Citizenship 267 (Rainer Bauböck ed., 2018).

and contract law, whose enforceability does not depend on the laws of any given country, but rather on the technological rules embedded into a particular blockchain infrastructure. In other words, blockchain technology could be considered as a "new means of securing legal protections" in outer space, despite the lack of an "international consensus on the sovereignty-property relation."[27]

In light of these above-described features, blockchain technology has come to be regarded as a promising vehicle for advancing decentralized markets that operate independently from any governmental authority.[28] This narrative of blockchain technology has also been leveraged for raising funds for outer space projects. One of the most well-known examples comes again from Elon Musk, who announced in May 2021 that a SpaceX mission to the Moon with an estimated cost of 62 million USD would allegedly be entirely funded in Dogecoins. There are many other initiatives that advertise blockchain-based fundraising for space ventures (such as Space Decentral[29] or ConsenSys Space[30])—although it remains to be seen if the money raised will indeed be used for commercial undertakings in outer space.

The problem with these blockchain-based initiatives is that they fail to acknowledge that enforcement cannot be achieved by blockchain technology alone when interacting with non-digital assets. Indeed, while blockchain technology and smart contracts are often said to be self-enforcing or self-executing, this only applies to digital contracts or digital assets that subsist exclusively on the blockchain. As soon as a blockchain-based infrastructure needs to interact with a non-blockchain-based structure, the trustless and self-executing features of the technology fall short—with regard to both collecting *inputs* and enforcing *outputs* outside of the blockchain infrastructure.

Whether a blockchain is used as a land-registry for outer space;[31] as a distributed platform to negotiate and record orbital positions and mining licenses;[32] as a traffic management system for the identification and the localization of satellites and space debris;[33] as a supply chain management system for space-related activities; or even as a smart contract framework to control the operations of physical devices[34]—all of these applications require, on the one hand, a trusted set of "oracles" that can feed the blockchain-based system with external information, and, on the other hand, a third-party enforcement authority that can intervene in case of a dispute. These issues are not specific to outer space; they apply to every application of blockchain technology that needs to interface with a non-blockchain-based structure.

Blockchain-based systems are thus not an effective work-around for the general dependence of private ordering on third-party enforcement institutions. While the Artemis Accords indicate that state-based legislation still has a considerable role to play despite the increased presence of private entities in outer space, how enforcement will be facilitated in outer space—and by whom—is still up for debate.

Alternative Blockchain Narratives for Outer Space

If the currently proposed applications for blockchain in outer space are inherently flawed—due to their dependence on external actors for access to information and for the enforcement of outcomes in the physical world—is there room for blockchain technology to make another potential contribution in the field of outer space?

[27] Cait Storr, *"Space Is the Only Way to Go": The Evolution of the Extractivist Imaginary of International Law*, *in* Routledge Handbook of International Law and the Humanities 295, 300 (Sundhya Pahuja & Shane Chalmers eds., 2021).

[28] *See Bitcoin as a Tool for Economic Empowerment* discussion with Cathie Wood, Jack Dorsey, and Elon Musk conducted by The ₿ Word.

[29] Space Decentral.

[30] ConsenSys Space.

[31] Diana, Blockchain Lunar Registry.

[32] Brian R. Israel, *Space Governance 3.0*, Ga. J. Int'l & Comp. L. 48 (2019)

[33] ConsenSys Press Release, ConsenSys Space Launches TruSat System (Oct. 21, 2019).

[34] NASA, *SensorWeb 3G Project*.

Beyond the libertarian ideology, blockchain technology has enabled other narratives that could contribute to promoting better governance in outer space fostering a more distributed and participatory framework for decision making. Collectives of researchers, activists, and developers are already experimenting with blockchain technology for the governance of the commons.[35] They believe this technology brings a long-missing piece to the commons' governance puzzle through the affordances it offers—e.g., reducing free-riding and enabling the collective management of funds.[36] Blockchain technology thus appeals to many grassroots communities[37] and decentralization advocates,[38] who see in this technology new opportunities for distributed and participatory governance.

Beyond grassroots communities, the technology could also serve the interests of both public and private space actors in enhancing institutional trust, not by relying on automated enforcement but rather by enhancing transparency and accountability. Indeed, blockchain technology is particularly well-suited for the governance of polycentric systems, where a variety of actors—often with diverging economic and political interests—need to come to a consensus about a particular course of action, without reliance on a centralized authority to coordinate their actions. Accordingly, many of the attempts at designing new distributed governance structures in the context of blockchain applications could potentially be transposed to the outer space field. A blockchain could be used, for instance, to support international cooperation and facilitate the reconciliation of transactions amongst multiple interacting actors through a shared database that is held in common by all relevant stakeholders. This is currently being done by the Space 4.0 initiative of the European Space Agency,[39] leveraging smart contracts to guarantee accurate payments, procurement, supplier agreements, and automated transactions. Besides, blockchain technology could help improve the governance of shared resources and distribute the proceeds of outer space resource extraction, thanks to the ability to manage funds in a transparent and decentralized fashion, with no reliance on any intermediary authority.[40]

Conclusion

Blockchain technologies are a powerful force of innovation with the potential to bring transformation in existing modes of governance. Yet, to date, most of the innovation facilitated by blockchain technology is driven by a particular set of libertarian narratives. These narratives have inspired a variety of applications in outer space, aimed at replacing sovereign rules with private ordering and market-based dynamics that could allegedly operate without the need for any governmental structure or trusted intermediary. Indeed, given the prohibition of national appropriation of celestial bodies, private ordering has become a popular mechanism to negotiate the allocation and exploitation of celestial resources. Yet, as we discussed in this essay, these applications are limited to the extent that they assume enforcement capabilities that the technology does not afford. Nevertheless, while the

[35] David Rozas, Antonio Tenorio-Fornés, Silvia Díaz-Molina & Samer Hassan, *When Ostrom Meets Blockchain: Exploring the Potentials of Blockchain for Commons Governance*, 11 SAGE Open 1 (2021).

[36] *Id.*

[37] *See, e.g.*, Crypto Commons.

[38] *See, e.g.*, Decentralized Web.

[39] As described in the European Space Agency's website: "Space 4.0 represents the evolution of the space sector into a new era, when space is evolving from being the preserve of the governments of a few spacefaring nations to a situation in which there is the increased number of diverse space actors around the world, including the emergence of private companies, participation with academia, industry and citizens, digitalisation and global interaction." European Space Agency, *What Is Space 4.0?*

[40] Isabel Feichtner & Andrea Leiter, *Proposal for a Study on the Scope, Purpose and Administration of a Global Fund from the Financial Payments from Deep Seabed Mining* (2020) (unpublished submission; on file with the author).

crypto-libertarian narrative may be the most noticeable one, blockchain technology has generated other narratives, providing new opportunities to experiment with more inclusive and participative commons-based or trust-based governance models. Those propositions have the potential to contribute to the governance of outer space as a global commons.