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The Empire Strikes Back: Comparing US and China's Structural Power in Outer Space

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This article assesses the structural power of the United States and China in the field of space governance. While much of the literature on space power focuses on their technologies and capabilities, we take a complementary approach and explore their capacity to shape the regulatory landscape. Possessing structural power has far-reaching implications for global power projection as well as for various industries, such as telecommunications, transportation, and remote sensing. To assess structural power, we gathered and analyzed three types of data: a dataset featuring 1,709 space organizations, a second dataset comprising 1,764 international space arrangements connecting them, and insights from fifty-two interviews with key space actors. Our findings indicate that the United States holds significant structural power thanks to its thriving commercial space sector and extensive international network. This has enabled the global diffusion of its preferred norms while simultaneously constraining China's space cooperation network. Despite its remarkable technological capabilities, China has not been able to translate them into substantial global structural power. To encourage further exploration in this domain, we make available our original dataset of 1,764 space arrangements, including 970 in full-text format, inviting fellow researchers to investigate other facets of outer space governance.

Este artículo estudia el poder estructural de Estados Unidos y China en el campo de la gobernanza espacial. Si bien gran parte de la literatura sobre el poder espacial se centra en sus tecnologías y capacidades, en este artículo adoptamos un enfoque complementario y exploramos su capacidad para dar forma al panorama regulatorio. El hecho de tener poder estructural tiene implicaciones de gran alcance para la proyección del poder global, así como para diversos sectores, tales como las telecomunicaciones, el transporte y la teledetección. Con el fin de poder evaluar el poder estructural, recopilamos y analizamos tres tipos de datos: un conjunto de datos procedentes de 1709 organizaciones espaciales, un segundo conjunto de datos que comprende 1764 acuerdos espaciales internacionales que conectan a estas organizaciones, e ideas extraídas de 52 entrevistas con agentes espaciales clave. Nuestras conclusiones indican que Estados Unidos tiene un poder estructural significativo debido a su próspero sector espacial comercial y a su extensa red internacional. Esto ha permitido la difusión global de sus normas preferidas y, al mismo tiempo, ha restringido la red de cooperación espacial de China. China, por el contrario, a pesar de sus notables capacidades tecnológicas, no ha sido capaz de traducirlas en un poder estructural global sustancial. Con el objetivo de fomentar un mayor interés en este ámbito, ponemos a disposición nuestro conjunto de datos original procedente de 1764 acuerdos espaciales, incluyendo 970 en formato de texto completo, e invitamos a otros investigadores a investigar otras facetas de la gobernanza del espacio exterior.

Cet article évalue le pouvoir structurel des États-Unis et de la Chine dans le domaine de la gouvernance spatiale. Tandis que la majorité de la littérature sur l'espace se concentre sur leurs technologies et capacités, nous adoptons une approche complémentaire pour nous intéresser à leur capacité à façonner le paysage réglementaire. La détention du pouvoir structurel s'accompagne d'importantes implications en matière de projection mondiale du pouvoir, mais aussi pour divers secteurs, comme les télécommunications, les transports et la télédétection. Pour évaluer le pouvoir structurel, nous rassemblons et analysons trois types de données : un ensemble de données où figurent 1 709 organisations spatiales, un deuxième comprenant 1 764 accords internationaux sur l'espace, et des informations issues de 52 entretiens avec des acteurs clés du domaine spatial. Nos résultats indiquent que les États-Unis détiennent un important pouvoir structurel grâce à un secteur spatial commercial florissant et un large réseau international. Ils ont ainsi pu diffuser leurs normes tout en limitant le réseau de coopération spatiale de la Chine. Malgré des capacités technologiques remarquables, la Chine n'a pas pu les traduire en un pouvoir structurel considérable à l'échelle mondiale. Pour faciliter les recherches ultérieures dans ce domaine, nous mettons à disposition notre ensemble de données inédit de 1 764 arrangements spatiaux, dont 970 textes complets, pour inciter la recherche portant sur d'autres facettes de la gouvernance de l'espace extra-atmosphérique.

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Introduction

China's space capabilities have made significant strides in recent years. In 2003, it launched its first crewed spacecraft, becoming the third country to independently send humans to space. In 2007, China successfully demonstrated its ability to disrupt space-based infrastructure by destroying one of its own weather satellites using a kinetic kill vehicle. The country's achievements continued with the very first successful landing on the far side of the Moon in 2019 and the completion of its BeiDou satellite navigation system in 2020, providing global coverage with an accuracy level comparable to the American Global Positioing System (GPS). In addition, China has launched its own modular space station and is currently developing plans for a permanent lunar base. These developments suggest that China is narrowing the gap with the United States in terms of outer space capabilities.

Numerous publications discuss the rivalry between the United States and China in outer space. Most of them argue that China is emerging as a space superpower, rapidly closing the gap with the United States (Johnson-Freese 2004; Liao 2005; Tellis 2007; Zhang 2011; Hilborne 2013; Goswami 2018; Wu 2022; Qisong 2023). Cheng suggests that the United States "faces its greatest space competitor since the dawn of the Space Age" in the form of China (2022), and Pollpeter asserts that China's space program "poses military, economic, and political challenges to the United States" (2020, 7). Sheehan goes as far as suggesting that China will soon be in a position to negate US space hegemony (2007, 167). There is also a growing number of governmental reports with titles like "Are We Losing the Space Race to China?" (US 2016) or "China's Ambition in Space: Contesting the Final Frontier" (US 2019), highlighting the level of concern within the US government apparatus. The 2023 Annual Threat Assessment report of the US intelligence community warns that "China's space activities are designed to advance its global standing and strengthen its attempts to erode U.S. influence across military, technological, economic, and diplomatic spheres" (US 2023, 8). Equally revealing of current anxieties is the proliferation of science fiction novels, movies, and television series depicting confrontations between China and the United States over the control of the Moon or the solar system.[1]

This article offers a different and complementary perspective by focusing on the structural power of the United States and China, which refers to their ability to shape the overall framework within which interactions among various actors occur (Strange 1988, 24). More specifically, this article assesses the respective capacities of the United States and China to influence global space governance, rather than comparing their material or technological capabilities. While structural power and capabilities are interrelated, they remain distinct concepts and one does not automatically translate into the other. Although capabilities may be more relevant for predicting the outcome of a particular conflict, having the capacity to define the rules of the game offers numerous long-term advantages, including for commercial profitability, intelligence gathering, and international prestige. Structural power also facilitates the accumulation of material and technological capabilities over the long term. In recent times, the stakes have heightened, with the burgeoning space industry, the impending race for asteroid mining, and the development of space-based broadband internet services. In this context, the space actor with the most structural power can expect a wide array of benefits stemming from its privileged position.

To assess US and Chinese structural power, we examine three original data sources: a comprehensive dataset of 1,709 space organizations, another dataset of 1,764 international institutional arrangements connecting these organizations (which we make publicly available on the journal's website and at www.institutions.space), and fifty-two interviews with key actors in this field (see the Online Appendix for information on the interviews and interviewees). Employing a mix of network analysis, descriptive statistics, and qualitative analysis, we find that the United States remains the main structural power in outer space governance and that China has not been able to translate its technological capabilities into substantial global structural power. This finding provides an important caveat to the common view that China is closing a historic gap.

This article is divided into four sections. The first section outlines our understanding of structural space power, which encompasses three dimensions: (i) the transnational reach of both public and private actors, (ii) network centrality that allows for leveraging a strategic position to influence the structure of the network itself, and (iii) rule-making capacity, which is the power to disseminate one's preferred rules. The subsequent sections each focus on one dimension of structural space power. First, we map the landscape of space actors and discuss the emergence of transnational private actors and its implications for the United States–China rivalry. Then, we look at global governance networks and identify patterns of cooperation and isolation that strengthen US centrality. In the third empirical section, we analyze the content of institutional arrangements and highlight the extent of US influence on global regulations. In the conclusion, we underscore the importance of structural power in fields as fragmented as the outer space governance system.

A Structural Understanding of Space Power

Power is a notoriously slippery concept. Most analyses of the distribution of power in outer space focus on capabilities. For instance, Lupton defines space power as "the ability of a nation to exploit the space environment," and he adds that it "includes the entire astronautical capabilities of the nation" (1988, 4). Similarly, Al-Rodhan argues that a "metageopolitics" of outer space "has to consider a number of unevenly distributed resources, or "capacities," to demonstrate the highly complex strategic relationships between states" (2012, 15). These analysts, however, disagree on how best to measure these capabilities. Some examine the control that different nations have over certain strategic locations in space, as Dolman (2002) does. Others, such as Liao (2005), assess a country's space capabilities in terms of its military intelligence, surveillance, reconnaissance, and anti-satellite capabilities. Still, other authors, such as Gray (1996), Hays (2002), Al-Rodhan (2012), Aliberti et al. (2019), Bowen (2020), and Pekkanen (2023) use a multidimensional measure of capabilities and study a broad range of indicators, including economic, scientific, diplomatic, and domestic support, as well as technological resources.

A few space analysts adopt a conceptualization of power that is not based on a measure of state capabilities. For example, Duvall and Havercroft (2008) investigate the constitutive effects of space-weapon technologies on the foundational ontology of the international system. In their view, the American empire is likely to expand its frontier into low-Earth orbit because of the centralization and

[1] Examples include *Red Moon* (2018) and *Space Force* (2020).

deterritorialization of sovereign power. Recently, some studies have adopted postcolonial or cosmopolitan perspectives to argue that the dominant discourses and institutions governing outer space reflect the views and interests of traditional colonizers to the detriment of marginalized populations (Aganaba-Jeanty 2016; van Eijk 2022).

This debate reflects broader discussions on the various dimensions of power in the field of international relations. Strange makes a pertinent distinction between relational and structural power (1988, 24). Power is often conceived in terms of relational power, including in the literature on space politics. It is the power of A to "get B to do something that B would not otherwise do" (Dahl 1957, 203). In this way, relational power is specific to the relation between A and B. Structural power is more diffuse and refers to the power to shape the framework within which interactions between various actors take place (Strange 1988, 24).[2] In poker, for example, relational power could be associated with having a royal flush or a full house, whereas structural power would be the privilege of deciding the rules of the game. Structural power does not necessarily require purposeful action on the part of the dominant actor, nor does it determine the actions of other actors. Instead, it provides the overall framework within which actors relate to each other.

This article focuses on structural power rather than relational power. These two forms of power are interrelated, as structural power enables specific uses of relational power, and, conversely, the repeated use of relational power can incrementally alter the distribution of structural power (Barnett and Duvall 2005, 44). For the purpose of this paper, we emphasize structural power because it serves as the foundation for the exercise of relational power (Strange 1987, 553). In many cases, relational power reflects structural power and reinforces the dominant actor's structural position (Winecoff 2020, 213). Since we confine our analysis to the structural power that the United States and China wield in outer space governance, we omit discussions of whether the United States can compel China to undertake actions it would otherwise not, or vice versa. This paper does not delve into direct power dynamics between the United States and China but rather examines each country's power projection in the context of global space governance.

We embrace Strange's definition of structural power while modifying her operationalization of the concept. Strange posits that power in world politics rests on four interrelated structures, which she likens to the four sides of a pyramid: security, finance, production, and knowledge (1987, 565). However, we are skeptical that this same four-part arrangement can be useful to understand power dynamics in specific governance domains, such as space governance. Other scholars such as Winecoff (2015) and Malkin (2022) have also adopted Strange's definition of power, but left aside her pyramidal approach to study power distribution in the specific fields of global banking and intangible assets, respectively. Instead, we direct our attention on three key dimensions of structural power: (i) transnational reach, (ii) network centrality, and (iii) rule-making capacity, as elaborated below.

First, Strange's framework of power structures invites us to consider the role of private transnational authority, in addition to public authority. The growth and reach of transnational corporations across boundaries have been supported by various public actors (Strange 1996). In turn, private transnational actors enhance the centrality and reach of public authorities from their home countries. In an area of global competition, public and private organizations from the same country cultivate symbiotic relations that benefit them both. Therefore, it is essential to view public and private authorities as part of an "integrated ensemble of governance" (Underhill 2000, 4). This ensemble is sometimes described as being heterarchical: It is a system made up of various autonomous units exercising fluid and diffused forms of authority (Belmonte and Cerny 2021). From this perspective, the traditional indicators of power, such as military expenditure and gross domestic product (GDP), do not provide a good measure of structural power as they are territorially bounded (Strange 1996; Starrs 2013). Instead, to assess the global reach of space powers, it is necessary to factor in the transnational activities of private actors (Moltz 2019).

Second, structural power exists within networks. Structurally powerful actors tend to rule as central actors within global networks, deriving their power from this position (Oatley et al. 2013; Winecoff 2015; Slaughter 2016). Therefore, it is necessary to analyze all actors and their relations as a whole rather than solely focusing on superpowers and their rivals. Strange was "more interested in the webs of structural power operating throughout the world system than in comparative analysis of discrete parts of it" (1997, 183). Network analysis is a method that can facilitate this holistic approach (Winecoff 2020). In international relations, network analysis often entails studying the topography of a system composed of actors who are connected through institutional arrangements, such as bilateral treaties (Kinne 2013), military alliances (Cranmer et al. 2012), or embassies (Duque 2018). In such a system, central actors are structurally privileged because they can access information from diverse sources more easily, enjoy broad social recognition, communicate their ideas widely, operate through intermediaries, and mobilize collective action more efficiently (Hafner-Burton et al. 2009).[3] As networks develop over time, central actors can leverage their strategic position to influence the very structure of the network, for example, by marginalizing certain stakeholders or by acting as a broker between two clusters (Farrell and Newman 2019). Informed by this structural perspective, Moltz suggests that transnational networks are a crucial dimension of space powers in the twenty-first century (2019, 17).

Third, structural power involves a regulatory capacity. If structural power is the power to decide the rules of the game (Strange 1988), we need to trace how rules emerge in global networks in order to examine power distribution. By prescribing certain behaviors and precluding others, rules can direct actors' behavior, modify the distribution of resources, impact interest calculations, create new identities, shape social relations, and establish shared meanings.[4] A key indicator of a structurally powerful actor is its capacity to disseminate its own rules in the governance of outer space and impede others to do so. Echoing this view, Deganit Paikowsky recently argued that "the future space race will be won not by those whose technological advancements are superior but by the rule-makers" (2023). Cheng (2023) notes that "amid the new space race, China is keen on establishing

[2]Our definition of structural power, borrowed from Strange, differs from the more limited conceptualization of Barnett and Duval. The latter restricts structural power to co-constitutive relations between two structural positions, which are "in direct relation to one another" (2005, 53).

[3]The centrality of superpowers is not incompatible with their transnational reach. On the contrary, in recent decades, power has become more centralized and more globalized (Duvall and Havercroft 2008; Babones and Aberg 2019).

[4]Thus, our understanding of structural power encompasses what Barnett and Duvall call institutional and productive power (2005).

the foundations of the legal infrastructure that will govern this key strategic arena" (see also Qisong 2023).

If we merely consider technical capabilities, which is the approach taken by several space analysts do, China may seem to be a contender to the United States. However, a closer examination of US transnational reach, network centrality, and global rule-making activities reveals a different picture of the structural power of China and the United States in outer space governance. These factors suggest that the United States's dominance as the structural superpower is firmly established and still expanding. The following section provides empirical evidence that the United States dominates the transnational space industry.

The Space Industry: One Small Step for China, a Giant Leap for the United States

We have created a dataset of space organizations to compare the transnational reach of US and Chinese organizations. For the purpose of our dataset, any organization that designs, owns, launches, operates, tracks, monitors, or regulates objects in space is considered a "space organization." This definition covers a wide range of entities, such as space agencies, armed forces, certification organizations, state-owned enterprises, public research institutes, large corporations, and small start-ups. However, it excludes consultancies, news organizations, lobby groups, and manufacturers of equipment used in ground stations and spacecrafts. The dataset covers organizations that were active at any point from 1957 (the year the Soviet Union launched Sputnik-1) to 2022 or have plans to launch or operate a spacecraft in the next 3 years. Our team of research assistants conducted extensive research utilizing various resources, such as D&B Hoovers and Crunchbase. Although collecting data on Chinese organizations is more challenging than gathering data on American organizations, native Mandarin speakers in our team conducted extensive research also in Mandarin language resources, including reports on China's space sector and China's official gazette. Our dataset comprises 1,709 space organizations with information on their location, founding year, size, launches, and activities.

Our analysis of the dataset reveals that the US space ecosystem is significantly more extensive, varied, and dynamic than its Chinese counterpart. The United States leads the world with the largest number of space organizations by a significant margin. Out of the 1,613 active space organizations in 2022, 382 (23.68 percent) are based in the United States, compared to 130 (8.06 percent) in China. It is noteworthy that the United States has more space organizations than China, Japan, the United Kingdom, Russia, and France combined.

After analyzing the rate of establishment of new space organizations in both the United States and China, we found no evidence to suggest that China will catch up with the United States in the foreseeable future. Although there has been a rapid increase in the number of space organizations in both countries since 2000, with around half of the existing space organizations created in this period, the gap between the two countries is widening. Since 2000, the United States has established 200 new space organizations, which is almost three times the number established by China (seventy-five). Despite the growing number of countries that now host space organizations, the percentage of space organizations headquartered in the United States has increased in the last decade, rising to 28.9 percent. In contrast, the share of other traditional space-faring nations, including Russia, has declined due to the increasing number of space organizations in developing countries.

As Figure 1 shows, the percentage of private organizations in the United States and China differs significantly. For the purposes of our study, private organizations refer to publicly traded or privately owned companies, non-profit organizations, universities, and business associations. Based on this definition, 65.0 percent of space organizations are private organizations. Compared with this global average, the share of private space organizations is particularly high in the United States (92.7 percent), and relatively low in China (61.5 percent). Of the 1,049 still active private space organizations we have identified globally, 33.8 percent are headquartered in the United States, while only 7.6 percent are based in China. It is likely that this gap will persist and even widen in the near future, consider current trends. Specifically, 96.9 percent of space organizations founded in the United States since 2000 are private, while only 76.4 percent of those in China.[5]

The United States space ecosystem's strength lies not only in its quantity of organizations but also in its diversity. Chinese organizations are concentrated in traditional space sectors, such as remote sensing, telecommunication, and navigation systems. Very few of them are active in emerging niches, including space tourism, space mining, human spaceflight, on-orbit servicing, and space traffic management. Like China, the United States counts more organizations in traditional than in emerging sectors. However, emerging sectors are considerably larger in the United States than in China, both in absolute numbers of organizations and in the proportion of the total number of organizations in each country.

Furthermore, US organizations exhibit greater diversity in terms of size. On one hand, US heavyweights, as measured by their number of employees or annual revenue, are significantly larger than their Chinese counterparts.[6] For instance, leading US space companies like Lockheed Martin Space Systems, SpaceX, and COMSAT are larger than their Chinese counterparts such as LandSpace and LinkSpace. On the other hand, the United States also has a higher number of small, highly specialized organizations and start-up companies. The US space ecosystem is characterized by a wide range of organizations, with large organizations providing long-term vision and capabilities, while smaller ones bring innovation and dynamism. In contrast, Chinese organizations have a lower standard deviation in size distribution, with more average-sized organizations.

In this context, the United States is in a unique position to exercise a gravitational pull on third countries. During our interviews (see the Online Appendix for more information), the CEO of a European space company told us: "The US is kind of the number one in space technology so lots of European countries look at what is happening in the US and they try to follow." This statement echoes a commonly held view. Another interviewee explained that the dominance of the United States in the space industry has implications in multilateral settings: "There has been a lot of reticence at the UN level to bring [. . .] private actors into the discussion [because] a number of countries [. . .] protest and say that

[5] This gap is partly the result of Chinese state-owned companies' nature.

[6] Data on the number of employees and revenue are missing for 36.5 percent of organizations and should be interpreted with caution. Data on the number of employees and revenue are also unreliable for organizations that are not entirely specialized in space activities. Nevertheless, our findings are similar to those of other datasets, including OECD 2019 and Bryce 2020.

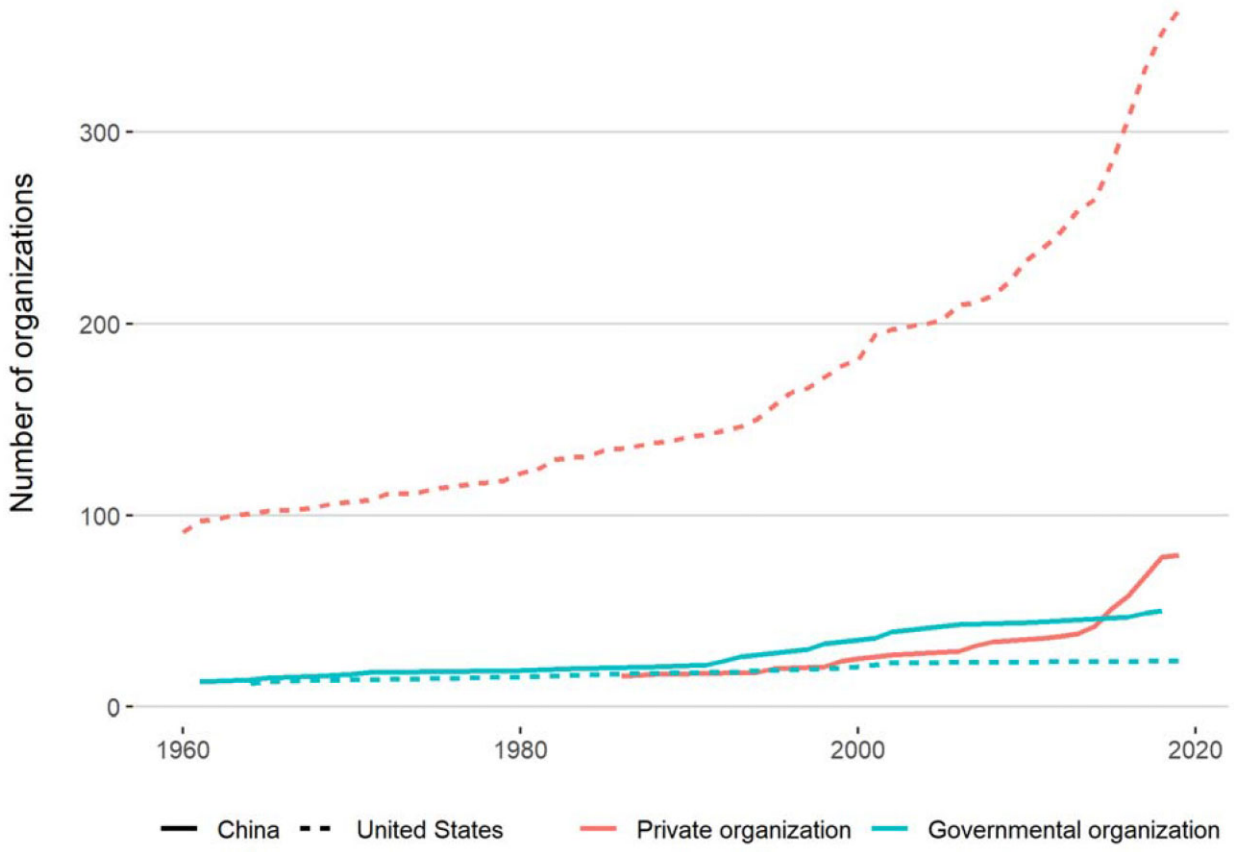

Figure 1. Cumulative number of public and private organizations in the United States and China (1960–2020).

the US will have too big of a voice if commercial actors [. . .] participate in [. . .] international dialogues."

The prevalence of US-based private organizations results from far-reaching governmental policies. In 2010, the Obama Administration issued a national civil space policy aimed at invigorating "competitive domestic industries." This policy instructed all government agencies to purchase space services from commercial companies whenever possible and to avoid developing space goods or services that could be procured from the private sector (US 2010). It also stated that the government would make its space technologies available to the private sector and incentivize the private sector to develop new technologies. The Trump Administration continued in the same direction and invited the private sector to take part in the flagship Artemis Program. The US government does not command but rather orchestrates its space industry, granting it ample autonomy and flexibility to thrive and expand (Mazzucato and Robinson 2018).

Chinese space policies do not prioritize the private sector to the same extent and in the same manner (Liu et al. 2019). China did adopt policies to encourage the commercial space sector in 2014 and invited private capital to invest in the construction of civilian space infrastructure.[7] However, Chinese policies and regulations include few measures favorable to space privatization and several restrictive rules regarding non-governmental participants in space activities (Nie 2020). Space activities remain predominantly military-dominated, resulting in strict and complex supervision of private entities (Nie 2022). Consequently, the gap between the US and Chinese space industries continues to widen.

Several interviewees emphasized the symbiotic relationship between public and private space organizations in the United States, extending beyond mere customer-provider transactions. NASA and US military agencies provide technologies, data, expertise, personnel, grants, legitimacy, and a long-term horizon to US space companies. For instance, in 2006, NASA awarded SpaceX, then a small start-up, $278 million to develop the Falcon 9 rocket and Dragon capsule. Private investment in the space sector soared in the following years, following SpaceX's initial success. In return, NASA and military agencies benefit from innovations, flexibility, agility, expertise, and influence derived from the emerging space industry. As the following sections discuss, private space actors have also contributed to expanding the international space network centered around the United States and promoting globally US-favored rules.

Spatial Network Analysis: US Centrality in Space Governance

Despite their significant size, number, and diversity, US space organizations cannot operate in isolation. They have concluded collaborative arrangements with counterparts worldwide. These arrangements are essential for pooling resources, sharing costs, exchanging information, developing shared understanding, and mitigating tensions (Deudney 1983; Krige et al. 2013; Cross 2019; Toyoma 2021). They also enable ambitious projects, such as the International Space Station or the Lunar Gateway. In this context, occupying a

[7]Guiding Opinions of the State Council on Innovating the Investment and Financing Mechanisms in Key Areas and Encouraging Social Investment, adopted November 16, 2014 <https://www.cpppc.org/en/zy/994006.jhtml>, section 24.

central position in the network of space arrangements provides significant benefits.

To assess the centrality of the United States in the outer space governance system (Del Canto Viterale 2023), we constructed an original dataset of international space arrangements. For the purpose of this dataset, we define international space arrangements as any written and voluntary arrangements uniting at least two space organizations from different countries. This definition includes treaties, protocols, memorandums of understanding, executive agreements, codes of conduct, guidelines, resolutions, industry standards, and information-sharing platforms. We found a total of 1,764 international arrangements that met this definition, of which 1,549 were still in force in 2023. We make available on the website of this journal this dataset of space arrangements in order to facilitate research on other aspects of global space governance.

Of the 1,764 space arrangements in our dataset, most are bilateral (70.0 percent), and only 3.0 percent include more than fifty parties. The growth rate in the number of arrangements is accelerating, with an average of 66.2 new arrangements concluded each year between 2010 and 2020. Although 46.7 percent of the arrangements were concluded exclusively between organizations based in high-income countries, an increasing share involves organizations based in developing countries. Most of the arrangements in our dataset involve at least one public organization, and a growing share has at least one private organization among its parties. However, contracts between private organizations tend to be confidential, leading to bias in our dataset. Nevertheless, this bias appears to be consistent across countries, including the United States and China, where the share of arrangements involving private organizations is proportional to their number of private organizations.

When we compare the set of all US and Chinese arrangements, striking disparities arise. Overall, US space organizations have joined 879 different international arrangements, which is more than double the figure for Chinese organizations (403 arrangements). This gap is widening as US organizations have collectively signed an average of 40.2 arrangements per year since 2010, while Chinese organizations have collectively signed an average of 18.3 arrangements per year over the same period. Consequently, 49.8 percent of our collection of 1,764 arrangements include at least one US organization, while only 22.9 percent include at least one Chinese organization. US organizations are party to more arrangements than their Chinese counterparts in each and every space sector, including telecommunications, defense, resource extraction, remote sensing, traffic management, navigation systems, and scientific research.

Another striking difference is the wider reach and diversity of US partners. Major space agencies, including the Japanese, British, European, and Russian space agencies, have all concluded more arrangements with US organizations than with Chinese organizations.[8] Furthermore, US organizations have been able to connect with more small players all over the world, including in developing countries.

As Figure 2 illustrates, US organizations have more arrangements with partners based in Europe, Africa, Latin America, and Asia than their Chinese counterparts. The United States is the primary partner for most countries, measured either by the number of arrangements or the number of partner organizations. This asymmetry is also noticeable in the relationship between China and the United States. For China, the United States is the first most important partner country measured by the number of partner organizations and the fourth most important partner country measured by the number of arrangements. In contrast, China is not even in the top-fifteen partner countries for either one of the two measures for the United States. The top three partner countries of China by number of arrangements, namely France, Brazil, and Russia, have concluded more arrangements with US organizations than with Chinese organizations.

Figure 3 shows a network of bilateral treaties, while Figure 4 shows a network of international arrangements concluded by governmental agencies and grouped by states. We limited these two networks to bilateral arrangements for clarity and ease of interpretation. The size of each country's three-letter name abbreviation is proportional to the number of partners it has. The two figures indicate that the United States holds a more central position than China.[9] We calculated various measures of centrality: Degree centrality is the sum of countries with which at least one arrangement has been concluded since 1957;[10] closeness centrality measures the shortest path to reach all other countries in the network; and eigenvector centrality measures the relative centrality of each country based on the centrality of the countries with which it has signed arrangements. Betweenness centrality is the number of shortest paths between two countries that go through a given country. Results appear in Table 1. The United States appears to be in a better position than China for each measure.

Several factors contribute to greater centrality of US organizations in the outer space governance system. One such factor is the gravitational pull that US organizations' mass exercises on the entire governance field. Many interviewees from other countries explained that US organizations were attractive due to their advanced technologies, renowned expertise, and unmatched prestige. They point to the accumulation of significant "soft power" (Nye 2004), cultivated by the US government. For example, the US government offers crucial space situational awareness data to its network of partners around the world, free of charge (Borowitz 2022). This invaluable service tracks debris and warns satellite operators of the risk of collision. For US partners, access to such information sustains loyalty and calls for reciprocity. As one interviewee claims, when "the US wants us to cooperate [it is] absolutely impossible to decline." Conversely, several interviewees pointed out that Chinese organizations appear reluctant to share data and information. One interviewee stated that they do not use the data provided by China because of their concern about its reliability.

A second factor that can explain US centrality is the weight of history and the legacy of early achievements, as well as cultural similarities or disparities. Well-established partnerships create self-reinforcing patterns of collaboration. A European interviewee explains that communication is effortless with their American counterparts because of their long history of collaboration with US agencies. Thus, divergent views are resolved rapidly. This is a good example of path dependency and the positive spillover effects of collaboration. The same interviewee added that "it is a little bit

[8]The Russian invasion of Ukraine may reduce the space cooperation between Russia and the United States, which is not reflected in our dataset.

[9]This centrality of the United States is consistent with the network analyses conducted by Borowitz (2022) on the space situational awareness sector, by Pomeroy (2019) on bilateral space arrangements concluded before 1979, and by the OECD (2020) on co-authorships in the space literature.

[10]These numbers can exceed the number of UN member states because they include former countries.

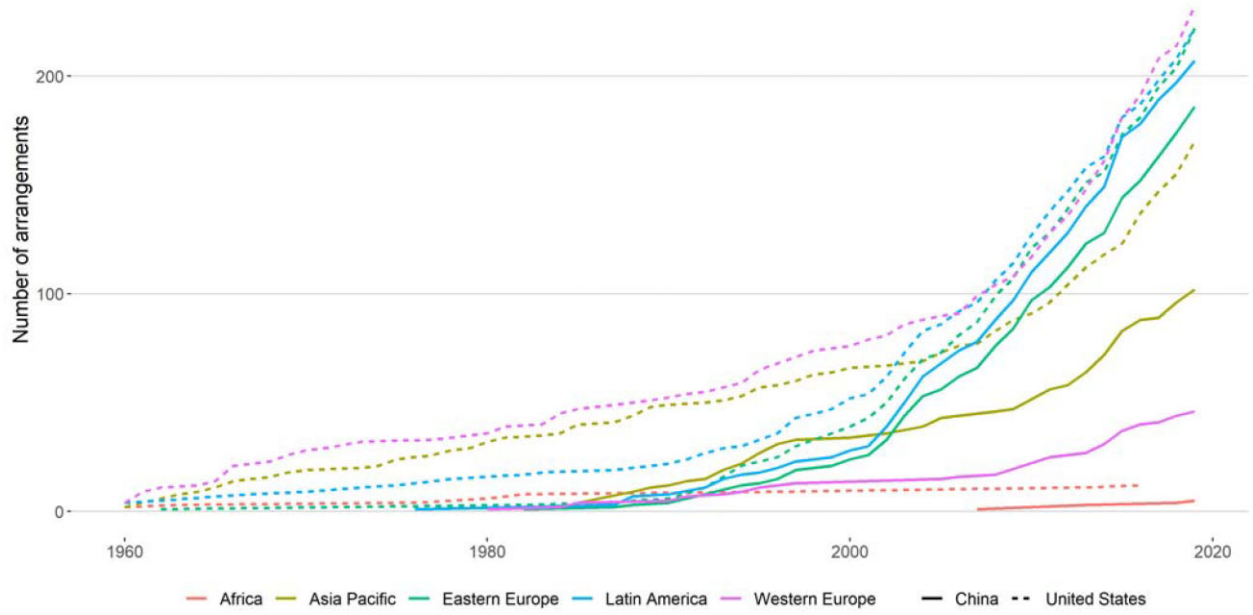

Figure 2. Cumulative number of arrangements signed by organizations headquartered in China or the United States with organizations based in different world regions.

Table 1. Centrality measures for the United States and China, based on Figures 3 and 4

	Degree centrality	*Closeness centrality*	*Eigenvector centrality*	*Betweenness centrality*
United States (Figure 3	138	0.008	1	0.064
China (Figure 3)	48	0.007	0,332	0.018
United States (Figure 4)	229	0.011	0,028	1
China (Figure 4)	45	0,010	0,021	0.104

more complex with the Chinese." Other interviewees noted that negotiating an arrangement with China was long, difficult, and arduous because of the multiple frictions caused by cultural differences.

Another explanation for the greater centrality of US organizations compared to their Chinese counterparts is the deliberate isolation of China by the US government. After some scientific and commercial space cooperation between the United States and China during the 1990s,[11] the situation changed at the turn of the millennium. The Cox Report, submitted to the US Congress in 1999, revealed that China had stolen or illegally acquired US missile and space technology, enhancing its military and intelligence capabilities. This report led to the adoption of strict export controls to prevent the introduction of US space technology to China (Noble 2008). These regulations extend beyond the United States and US companies, as they apply to US-origin products and technologies worldwide, including foreign products containing US-origin components or incorporating US-origin technology subject to US export controls. Furthermore, in 2011, the US Congress enacted the Wolf Amendment, which prohibits NASA from using government funds to cooperate with Chinese organizations. This legislation effectively closed the door to China for space cooperation with the most prominent space actor.

These US policies dissuade foreign organizations from collaborating with China.[12] During our interviews, several CEOs and legal counsels of space companies based in third countries (not the United States or China) told us they were "afraid [. . .] to violate US export control regulations" and considered that "any hint of Chinese involvement will cause problems with US regulators." They explained how they felt obliged to choose between working with the United States or with China, and that they could not afford to leave the United States aside because "there are almost always American components in space projects." According to the CEO of a space company: "We wish to work with the US [and] the US has the capability of punishing companies who do not follow the rules." Another CEO echoed this sentiment, stating: "If you want to work with the US, it is not in your interest to have a collaboration with China." As a result, China has access to fewer partners, some of whom may offer products and services of lower quality. Several European interviewees cited US policies and regulations as reasons why they have "no plans to work in China" and why "China will wait." These US policies inflict a glass ceiling on China's global space network, limiting its ability to collaborate with other actors.

[11] There was some scientific cooperation between US and Chinese space organizations in the early 1990s (Zhang 2021). For example, the Columbia and Discovery shuttles carried experiments for Chinese scientists, and the Chinese Long March rockets launched satellites for the United States. However, this occasional cooperation has become increasingly rare and superficial.

[12] A Euroconsult report notes that "few foreign space companies [do] business in China" (2021).

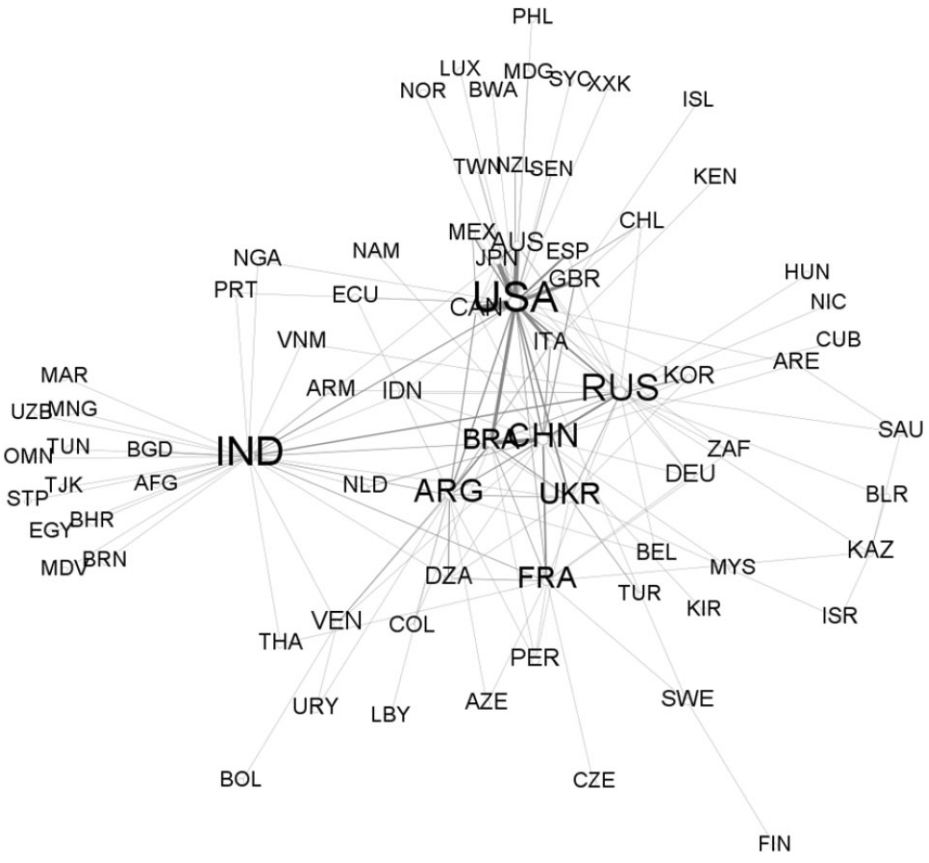

Figure 3. Network of bilateral treaties concluded by states.

While any actor can choose not to work with another, only those with structural power can marginalize others from a global network and create what Farrell and Newman call a "chokepoint effect" (2019). The power to exclude is a feature of structural power.

Relatively isolated from international networks, China has had to build its own capacity. Although its space capacity initially relied on Soviet and US technologies, self-reliance quickly became a key goal of the Chinese space program (Zhang 2021). While the International Space Station is a collaborative project involving the United States, Russia, Europe, Japan, and Canada, the Chinese space station is solely a Chinese initiative.[13] If anything, the Chinese insistence on self-reliance further accentuates China's marginalization in global space networks.

The Chinese space sector is not entirely isolated, as Chinese space organizations actively pursue collaborations. They frequently conclude memorandums of understanding with foreign organizations and participate in UN debates on space governance (Long 2016). However, Chinese organizations gain relatively little in terms of additional capabilities and technologies from their international cooperation (Zhang 2021, 372).[14] A notable example is the establishment of the Asia-Pacific Space Cooperation Organization (APSCO) in 2008, actively promoted by China and headquartered in Beijing.[15] Its members include Bangladesh, Iran, Mongolia, Pakistan, Peru, Thailand, and Turkey. These partners are unlikely to significantly contribute to the technological development of the Chinese space program or provide substantial funding for joint projects. Similarly, China builds, launches, and operates satellites for countries such as Venezuela, Nigeria, Sri Lanka, Belarus, Djibouti, and Laos. Once again, these relationships are highly asymmetrical because China possesses significantly more space capabilities and financial resources than these partner countries. Additionally, China's Belt and Road Initiative (BRI) includes a space component, known as the BRI's Space Information Corridor, which will include earth observation, communications, and navigation satellites serving all the countries along the BRI (Nie 2019). Moreover, the state-owned China Great Wall Industry Corporation leads China's efforts to dominate the international launch and satellite markets, including by offering generous state-backed financing (Messier 2019). While China derives some revenue and diplomatic influence from these collaborations, it gains little in terms of new technologies (Al-Rodhan 2012, 139).

China's group of partners does not rival the alliance that the United States recently established for its Lunar Artemis Program. The US-led Artemis Accords have attracted a steadily growing number of countries. At the time of writing, the twenty-nine parties to the Artemis Accords include countries such as Australia, Brazil, Canada, France, India, Israel, Italy, Japan, Mexico, Saudi Arabia, Singapore, South Korea, and the United Kingdom. Many of these partner countries can provide meaningful technologies or financial contributions to the US-led Artemis program. China and Russia, on their side, have a joint plan to establish an International Lu-

[13] However, China has declared that it will be open for future collaborations.

[14] That does not mean that Chinese organizations never develop technological cooperation with other space-faring nations. On cooperation between China and Europe, see Johnson-Freese and Erickson (2006).

[15] APSCO was built on the Asia-Pacific Multilateral Cooperation in Space Technology and Application, created in 1992.

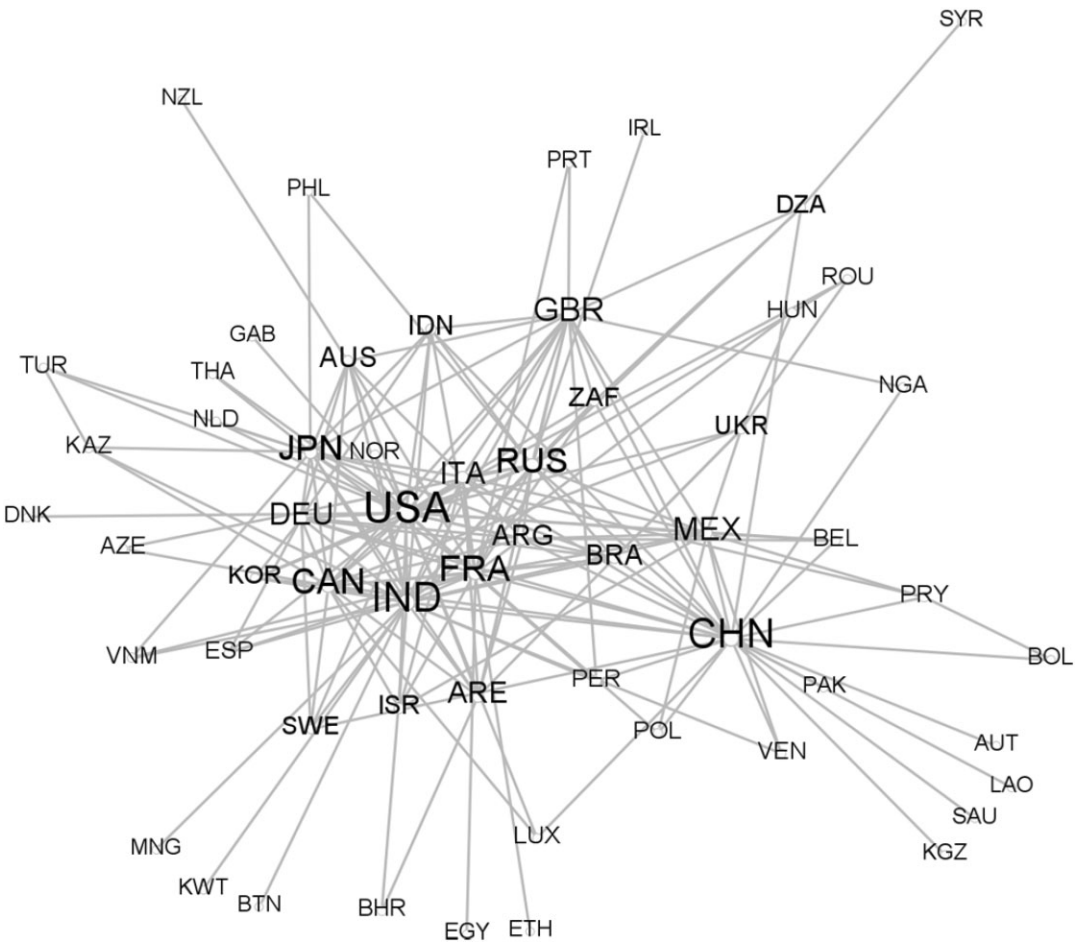

Figure 4. Network of bilateral arrangements concluded by governmental agencies and grouped by states.

nar Research Station to compete with the US Artemis Program. Their project is explicitly "open to all interested countries and international partners," and a "Guide for Partnership" has been circulated (CNSA & ROSCOSMOS 2021). However, as of now, only four countries (Venezuela, Pakistan, the UAE, and South Africa) have joined China and Russia's project (Li and Mayer 2023). The potential financial and technological contributions from these countries are notably less than what the countries that have joined the US-led Artemis, encompassing all of the world's top ten economies except for China and Russia, can offer.

Not all space organizations systematically prioritize their relationship with the United States over China. In fact, several interviewees told us that they did not want to align themselves too closely with the United States. Many try to remain on "neutral ground" and "talk with everybody"; they are "open to deal with everybody" and try to avoid "joining gangs"; they express the wish to put their "eggs in different baskets" or act like "bridge builders." However, these efforts are insufficient to create a balanced system. The global governance system for outer space remains heavily tilted in favor of the United States.

Centrality in global space networks provides several advantages to the United States. Allies and partners with strong space capabilities provide technologies, data, knowledge, and funds that can be combined, assembled, or triangulated. This includes more accurate positioning systems, information on small objects in orbits, and the use of highly specialized space robots. Global networks increase resilience and drive the development of both civil and military systems. The diversity of US allies also enables specialization by building on each partner's competitive advantages. For example, New Zealand might not be an economic powerhouse, but it offers unique launch sites as it is surrounded by open seas and located near polar orbits (Toyoma 2021). The US broad network also provides a strong basis for coalition building in multilateral settings, as the growing number of countries joining the US-led Artemis Accords demonstrates. In contrast, the Chinese network does not offer such extensive benefits.

The Astro-Regulator: The Diffusion of US Norms

This section presents evidence that the United States leverages its transnational reach and network centrality to shape key rules governing outer space activities. Many of these rules are formalized in US arrangements. To obtain the full text of the 1,764 arrangements identified, we reached out to numerous organizations, submitted formal information requests to various government agencies in several countries, and collaborated with multiple archive centers. Ultimately, we were able to collect 970 arrangements in full texts (54.9 percent), which we also make available for other researchers. An analysis of these documents reveals the extent to which the US regulatory capacity exceeds that of China.

One evidence of the US regulatory capacity is that American arrangements are not only greater in number but also stronger in their legal strength. The majority of international arrangements concluded by US organizations (56.66 percent) are legally binding. They include many contracts and treaties. In contrast, most Chinese arrangements (81.14 percent) are not legally binding but take the form of memorandums of understandings, exchanges of letters, or joint statements. Another key difference is their degree of specificity in their commitments. US arrangements generally contain an operable section that outlines specific obligations, details a specific joint project, creates a joint organization, or provides for the provision of goods, data, or services. In contrast, most Chinese arrangements merely express goodwill and a general interest in cooperation. They tend to be weaker and less specific than American arrangements.

A significant illustration of the structural rule-making capacity of the United States is the Artemis Accords (Riordan et al. 2023). The Artemis Accords is a significant example of the United States's ability to diffuse its favored rules for space governance. It was designed by the US government to create an international alliance around NASA's Artemis lunar program. It provides a framework for cooperation, including a set of operational principles to govern civil space activities. Notably, the Artemis Accords open the door for "the extraction and utilization of space resources, including any recovery from the surface or subsurface of the Moon, Mars, comets, or asteroids" (section 10.2). To avoid harmful interference during extractive activities, the Artemis Accords provide for the creation of "safety zones," where operations can be carried out (section 11.7). The US government claims that the provisions comply with the 1967 Outer Space Treaty. However, some space experts and state representatives contend that they contradict the treaty's principle of non-appropriation (Boley and Byers 2020). At the very least, the Artemis Accords interpret the non-appropriation principle according to US interests and worldview. Unlike some nations, the United States rejects the idea that space is a "global commons" (US 2020) and grants private entities the right to own and sell extracted space resources (US 2015). By providing operational guidelines for the extraction of space resources by private entities under contract with civil space agencies, the United States shapes global space governance to suit its own preferences. It does not promote this particular understanding of the non-appropriation principle in the framework of a multilateral forum. Instead, it invites key bilateral partners to sign the Artemis Accords as a prerequisite for participation in NASA's flagship Artemis program, a compelling incentive for foreign states. Two years after the Artemis Accords opened for signatures in October 2020, it had already been signed by twenty-nine countries and one territory. Signatories include France, which is traditionally somewhat reserved about the US perspective, Brazil, one of China's key allies, and India, another BRICS country.

The United States also employs its network of arrangements to promote its view of the global space launch market. In the 1990s, the United States sought to broaden its pool of launch providers for commercial satellites and concluded arrangements with countries like Ukraine, Russia, and China for commercial space launch services.[16] The objective was to create an "environment characterized by free and fair trade" among space launch providers and to encourage "market-oriented reforms" in this sector (1996 US–Ukraine agreement, art. 1). These arrangements uphold free market principles, prohibiting dumping practices, discriminatory measures, and trade-distorting subsidies. They also provide a detailed definition of prices that are considered below market value. Alongside these free-market dictates, the United States imposed quantitative restrictions on the number of launches that foreign countries can offer to international customers (1995 US–China Memorandum of Understanding, art. II; 1993 US–Russia agreement, art. IV; and 1996 US–Ukraine agreement, art. V).

Recent US arrangements seek to extend US policy restrictions on the export of space technologies to China globally. At least thirty US bilateral arrangements prevent foreign countries from transferring goods or technologies to third parties that do not comply with US export control measures. For example, an arrangement concluded in 2000 facilitates the transfer of technologies to Canada, provided that the Canadian government implements an export control scheme similar to the United States. It includes several measures to prevent the transfer of US technologies to China (Choi and Niculescu 2006). Likewise, the United States has concluded bilateral arrangements with New Zealand (2016), Brazil (2019), and the United Kingdom (2020), preventing these countries from launching aircraft that do not comply with the US's export policy. These restrictions on foreign soil are controlled by diverse measures, including prior notifications, a licensing scheme, and on-site inspections. These measures also restrict the use of equipment, technology, manpower, or funds from countries that are not part of the US-led Missile Technology Control Regime, including China.

Some rules favored by the United States have spread in the network of space arrangements and appear in bilateral arrangements that do not include the United States. Several bilateral arrangements between third countries, including some of China's allies, now require compliance with export control licenses and prohibit the exports of space technologies to countries that are not part of the US-led Missile Technology Control Regime. We found provisions of this type in more than twenty-six bilateral arrangements that do not involve the United States. Some arrangements even contain word-for-word transcriptions of clauses taken from earlier US-led arrangements. As an interviewee working for a European space company notes, "Everybody is basically acting on US facts [. . .] even when not working directly with the US." Thus, the US' preferred rules are being perpetuated without direct US involvement.

The US' regulatory reach extends beyond formal rules. As one interviewee observed, the United States has so much clout that some of its rules remain informal: "You listen, you understand, you read between the lines." Another interviewee explained that compliance with unwritten rules is "understandable" and "normal" to avoid "receiving phone calls from Washington." One recent example of this normative influence relates to anti-satellite weapons tests. In April 2022, the United States was the first country to publicly announce that it would refrain from conducting anti-satellite weapons tests due to the large amounts of debris they create. This was a direct response to the Chinese, Indian, and Russian anti-satellite tests that took place in 2007, 2019, and 2021, respectively. In the weeks following the US announcement, several US allies made similar unilateral pledges, including Australia, Austria, Canada, France, Germany, Italy, Japan, the Netherlands, New Zealand, South Korea, Switzerland, and the United Kingdom. In December 2022, at the initiative of the United States and its allies, the UN Gen-

[16]Launches from China were later prohibited.

eral Assembly approved a resolution (A/RES/77/41) calling upon "all states to commit not to conduct destructive direct-ascent anti-satellite missile test," with the supporting vote of 155 countries, but the opposition of Russia and China.

No other country exercises this level of regulatory power. An alternative approach to the US perspective on outer space governance was formalized in the 1979 Moon Agreement. This treaty states that the Moon's natural resources are "the common heritage of mankind"; they cannot become private property; and their exploitation should be governed by an international body to ensure that the benefits are shared equitably with all countries, taking into account "the interests and needs of developing countries" (art. II). Despite being signed over forty years ago, only eighteen countries have ratified the Moon Agreement, fewer than the 2020 Artemis Accord. Moreover, the parties to the Moon Agreement are mostly developing countries with limited space capacity. It is worth noting that neither China nor Russia has joined the Moon Agreement or presented an alternative approach for the exploitation of space resources and the distribution of space benefits.

Another attempt to challenge the US regulatory approach concerns the prevention of an arms race in outer space. China and Russia have been advocating for a treaty to regulate the placement of weapons in outer space since the early 2000s (Byers and Boley 2023, 275). In 2008, they presented a draft Treaty on Prevention of the Placement of Weapons in Outer Space to the United Nations Conference on Disarmament to create momentum for their proposal. When it failed to gain sufficient traction, they proposed a revised version in 2014. However, the United States rejected the proposal on the grounds that it does not cover terrestrially based anti-satellite weapons, which the United States considers to be the greatest threat to outer space systems, and the absence of a verification mechanism. The United States also appears uninterested to use international hard law to regulate the weaponization of outer space (He 2023).

After 20 years of discussions on the prevention of an arms race in outer space, China and Russia have failed to leverage their networks to conclude a treaty on the demilitarization of space. This failure of the Chinese and Russian initiatives is partly the result of an active "antipreneurship" campaign orchestrated by the United States (Bower and Lantis 2023). Meanwhile, the United States and its allies have successfully promoted various initiatives to regulate anti-satellite weapons, including ground-based systems, under the umbrella of "responsible behavior in space" or for the "long-term sustainability of outer space activities." Furthermore, the North Atlantic Treaty Organization (NATO) has expressed concerns for terrestrially based anti-satellite systems and made it clear that an attack on a member's assets in space will be considered as an assault on the alliance (NATO 2022). This illustrates the US's capacity not only to diffuse its preferred rules but also to prevent the diffusion of rules that it opposes.

Conclusion

Structural power confers the ability to shape the overarching framework of interactions. In the realm of global space governance, the United States emerges as a structural superpower. Utilizing original datasets from space organizations and arrangements, we determined that the United States possesses the greatest transnational reach, network centrality, and rule-making capacity. While several other countries also have a noteworthy level of transnational reach and network centrality, the United States not only surpasses these nations in these metrics but also boasts a significant rule-making capacity. The influence of the United States extends well beyond its borders and contractual agreements, affecting non-US entities and arrangements that do not even involve a US organization. Its export control rules create a barrier that limits China's ability to expand its space cooperation network. Consequently, China primarily collaborates with developing countries that have limited capabilities or countries that are at odds with the United States. This constrained network denies China access to the technologies, resources, and political influence that the US garners from its extensive connections with other space-faring nations. As evidenced by the recent Artemis Accords, the United States effectively disseminates its favored norms and regulations. In stark contrast, China has been unsuccessful in regulating the deployment of weapons in outer space over the past two decades.

Space governance is currently undergoing a rapid proliferation and diversification of actors (Tepper 2022). As the space industry grows and new countries enter the space race, space governance is no longer the sole domain of a few space agencies. In this context, the primary multilateral treaties governing outer space appear increasingly inadequate for tackling emerging challenges. This governance gap is increasingly being filled by various types of bilateral arrangements. This study suggests that these trends do not necessarily signify a waning of US influence. On the contrary, we present evidence that the increasing complexity of governance systems might amplify the relative control of pre-existing powerful actors (Drezner 2009; Morrison et al. 2019). The proliferation of informal forums and bilateral initiatives enables the United States to "weaponize" its structural advantage and propagate its favored norms through non-multilateral channels (Farrell and Newman 2019). This phenomenon is sometimes termed "complex hegemony" (Scholte 2020). We advocate for further research into this intricate governance system and, to aid this endeavor, are releasing our dataset of 1,764 space arrangements with this article's publication, including the full text of 970 of them.

Our findings contribute to the ongoing debate about the relative power of the United States and China. They resonate with studies that challenge conventional wisdom, showing that China's structural reach is notably less extensive than that of the United States (Oatley et al. 2013; Starrs 2013; Winecoff 2015, 2020; Fichtner 2017; Liu and Tsai 2021). While China's power is on the rise, its technological advancements are commendable, and some of its initiatives pose challenges to the US-led order, it does not appear poised to assume the role of the next global regulator (Breslin 2021). Although much of the discourse on space politics focuses on capabilities and relational power, this article underscores the value of examining structural power for a distinct and supplementary viewpoint. Susan Strange's observation that scholars, particularly those from the United States, tend to be overly concerned about the United States's declining hegemony remains relevant today, at least in the realms of space governance (1987, 553).

Supplementary Information

Supplementary information is available at the *Global Studies Quarterly* data archive.

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