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Hybrid organisations and governance systems: the case of the European Space Agency

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ABSTRACT

The constitutive organisations of governance systems tend to multiply and diversify over time. In parallel, a tendency toward homophily favours the creation of clusters of homogeneous organisations. Yet, few systems drift to the point of disconnection or dislocation. Several remain sufficiently cohesive to allow adaptation and other complex properties to emerge. To maintain equilibrium between order and chaos, some organisations must create bridges between otherwise homogeneous groups. This paper argues that hybrid organisations are ideally suited for this role. By their nature, hybrids share characteristics with different types of organisations in global governance, allowing them to overcome strict homophily and create bridges across clusters. Hybrids benefit from acting as brokers and in doing so, they facilitate the exchange of material and ideational resources across the governance system. Even if it is not their intention, they contribute to holding governance systems together and counterbalance the effect of homophily. We illustrate this argument by examining the space governance system and the hybrid nature, bridging activities, and brokerage role of the European Space Agency.

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KEYWORDS Space governance; European Space Agency; homophily; hybridity; complexity; network analysis

Introduction

As governance systems grow in size and diversity over time, what prevents them from fracturing into different clusters of homogeneous organisations? The existing literature in international relations has extensively documented the proliferation of organisational actors and their institutional arrangements (Abbott & Faude, 2022; Abbott & Snidal, 2021), as well as the tensions and

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mismatches that arise in governance systems as a result (Alter & Meunier, 2009; Hofmann, 2019; Raustiala & Victor, 2004). Recent work in organisational studies meanwhile has found evidence that organisations are more likely to collaborate with organisations sharing similar characteristics to them (Atouba & Shumate, 2015; Murdie, 2014; Sapat *et al.*, 2019; Wang & Shin, 2023). However, few studies have investigated the consequences of homophilic preferences for the structure of global governance systems, and even fewer have explored how this tendency can be counterbalanced.

In this paper, we argue that hybrid organisations can mitigate the fragmenting effect of homophily on a governance system. Hybrid organisations share characteristics with different organisational forms. This peculiar nature facilitates the conclusion of institutional arrangements with different types of organisations and, thereby, helps to create bridges across clusters of organisations. Hybrids can then take advantage of their strategic position to act as brokers and, in doing so, facilitate the distribution of resources across clusters of otherwise homogeneous organisations. By establishing these bridging ties and conducting self-serving brokering activities, hybrids contribute to holding governance systems together, even if this is not intentional.

To be clear, the aim of this paper is not to provide a comprehensive explanation of system fragmentation or defragmentation. Homophily is only one determinant of partnership formation[1] and it alone is not enough to explain the structural characteristics of a governance system. Rather, we contend that, *ceteris paribus*, homophily can lead to fragmentation and that hybrid organisations can (intentionally or not) mitigate this type of fragmentation.

We illustrate our argument by analysing the role played by the European Space Agency (ESA) in the outer space governance system. Over the years, various types of organisations became involved in governing outer space. Despite organisations' homophilic tendencies, space governance exhibits characteristics closer to a complex system than a fully fragmented one. Based on a network analysis of 240 space organisations connected by 1189 international bilateral institutional arrangements, along with 52 semi-structured interviews with key players, we demonstrate ESA's instrumental role in maintaining the space governance system together. More specifically, ESA's hybrid nature as an international organisation, a space agency, and an industrial policy actor enabled it to sign arrangements with various organisations, keeping the global space governance system connected.

In developing this argument, we contribute to the literature in three ways. First, we provide evidence of homophilic patterns in global governance using a dataset of institutional arrangements signed in space governance from 1960 to 2019. While recent scholarship has emphasized how organisational forms tend to replicate themselves in global governance (Abbott *et al.*,

2016; Green & Hadden, 2021; Lake, 2021), few have looked at how organisational homogeneity affected international cooperation. Second, we articulate an original theoretical argument on the role of hybrid organisations in governance systems, explaining how such systems remain cohesive despite individual homophilic preferences. In so doing, we offer a novel explanation for how governance systems can remain organically cohesive even in the absence of intentional orchestration. Recent applications of complexity ideas in international studies have yet to consider how homogeneity and hybridity affect the structure of governance systems (Beaumier *et al.*, 2023; Orsini *et al.*, 2020; Winston, 2023). Third, we offer empirical evidence demonstrating ESA's contribution as a hybrid in maintaining the relative cohesiveness of the space governance system.

In the first section, we develop our argument in relation to the literature on complexity, homophily, and hybridity. In the second, we present our data and methodology. In the third, we offer an operational definition of fragmentation and complexity and showcase how the space governance system has evolved as a complex system. In the fourth, we focus on ESA's hybrid nature, enabling it to create bridging ties across different groups of homogeneous space organisations. We contrast it with NASA, the second most central organisation according to our analysis. We then demonstrate how ESA used its network position to act as a broker in the space governance system.

Complexity, homophily and hybridity

The expansion of global governance systems

We hereafter conceptualise *governance systems* as networks of actors connected by institutional arrangements governing a given issue area (Eilstrup-Sangiovanni, 2016).[2] The global governance system for timber, for example, consists of a network of non-governmental organisations (NGOs), industry groups, and governmental organisations connected by various certification schemes (Zeitlin & Overdevest, 2021). Similarly, the global governance system on infectious disease includes NGOs, intergovernmental organisations (IGOs), and private foundations connected by different types of initiatives and partnerships (Abbott & Faude, 2022; Atouba & Shumate, 2010).

Global governance systems exhibit a notable propensity to expand. While stagnation or atrophy are conceivable outcomes, their expansion is a recurring pattern in international studies (Alter & Raustiala, 2018; Weiss & Wilkinson, 2014). This trend results from two intertwined processes: the proliferation and diversification of international actors *and* their institutional arrangements.

First, the number and diversity of actors involved in global governance systems have grown significantly. While the total number of sovereign

states has been relatively stable since the end of the Cold War, the number of non-state actors on the international stage has surged. These actors include scientific associations, unions, federated entities, industry groups, private foundations, parliamentary associations, regulatory agencies, and cities (Cerny, 2022). Keohane and Victor (2011) rightly characterised this upsurge as a 'Cambrian explosion'. Although a few international actors disappeared (Eilstrup-Sangiovanni, 2020), these losses have been overcompensated by the entry of new or existing organisations onto the international stage (Abbott *et al.*, 2016; Orsini *et al.*, 2013; Raustiala, 2012).

Second, there is a growing trend among international actors to establish institutional arrangements to regulate their activities. Abbott and Faude aptly observe that governance systems populated by heterogeneous actors and arrangements are 'widespread in contemporary global governance' and 'can be observed in numerous issue-areas' (2022, p. 2). These arrangements[3] significantly take many forms, including coalitions, standards, umbrella organisations, partnerships, clubs, codes of conduct, and memorandums of understanding. Just like the average state is party to an increasing number of treaties, the average transnational corporation is joining an increasing number of partnerships.

Homophily and fragmentation

While several studies document the proliferation of international actors and institutional arrangements (Abbott & Snidal, 2021), few analyse the implications of their growing diversity in terms of organisational forms. Most studies of global governance systems focus on a singular organisational form and its corresponding arrangements, such as states connected by treaties (e.g., Morin, Pauwelyn *et al*., 2017), intergovernmental organisations connected by cooperative arrangements (e.g., Downie, 2022), or businesses actors connected by certification schemes (e.g., Auld, 2014). As Keohane and Ostrom noted: 'Although heterogeneity has been obvious to empirical researchers, too little theoretical work has explored its consequences' (1994, p. 7). Thirty years later, this assessment of the literature still holds true.[4]

As global governance systems become increasingly diverse, organisations often tend to form relationships based on homophily, i.e., with partners sharing a similar organisational form.[5] 'Birds of a feather flock together', as the saying goes. Social psychologists extensively document how homophily shapes interpersonal ties, such as marriage, employment, and business partnerships (McPherson *et al.*, 2001; Wang *et al.*, 2016).[6] Organisational studies also suggest that homophily plays a role in shaping inter-organisational partnerships. For example, research finds NGOs are more likely to collaborate with other NGOs (Atouba & Shumate, 2015; Murdie, 2014; Sapat *et al.*, 2019) and IGOs with other IGOs (Wang & Shin, 2023). Although few studies in global

governance comprehensively examined this question, there are indications that similar homophilic patterns are also at play. Abbott and Snidal note that most regulatory schemes emerge from the cooperation among governmental actors *or* business actors (2009, p. 53). Building on the latter's work, Pattberg and Widerberg (2020, pp. 383–384) find that most regulatory schemes dealing with climate change, forestry and fisheries result from cooperative work among similar actors (governmental actors, business actors or NGOs).

Organisational homophily offers many advantages to organisations looking to establish cooperative relationships. Previous studies note that partnerships among similar organisations reduce the risks of cooperation failure (AbouAssi *et al.*, 2021). Having a similar organisation form limits the risks of costly conflict among partners over policy design or implementation. Homophily can also reduce transaction costs as similar organisations tend to face fewer barriers to cooperation (Atouba & Shumate, 2015). As a result, homophily eases partnership formation and promotes a more intensive form of cooperation.[7]

However, the tendency of individual organisations to favour homophily can have systemic effects, with significant consequences for governance system structures (Schelling, 1971). Specifically, homophily can create fragmentation. If organisational actors primarily conclude arrangements with similar actors, the governance system will gradually become partitioned among increasingly divided communities of similar actors or, in network terminology, more modular over time (Maoz, 2012). This, in turn, leads to a greater average distance between actors of different nature. In extreme cases, it could lead to fully fragmented systems of disconnected subgroups of organisations.

The risk of excessive fragmentation due to homophily increases as governance systems expand over time. In smaller systems, actors' homophilic preference is less pronounced (Currarini *et al.*, 2016). However, as a group grows, the tendency to partner with similar actors increases. This is because transaction costs rise as systems become more diverse and populated, making it more appealing to collaborate with similar partners. Moreover, homophily reinforces itself as the formation of embryonic homogeneous clusters increases the transaction cost of collaborating with distant partners from other clusters. Thus, even a low degree of homophily can eventually lead to a highly fragmented system (Yavaş & Yücel, 2014).

This fragmentation can have adverse consequences for both actors and the governance system as a whole. At the actor level, fragmentation creates echo chambers depriving them of useful information and knowledge generated by others of different natures (Eilstrup-Sangiovanni, 2016). Similar actors become stuck together in dense clusters through strong ties (Granovetter, 1973). This isolation creates a 'competency trap' in which actors

become increasingly less able to learn and innovate (Beaumier *et al.*, 2023; March & Olsen, 1998). It reinforces an insider-perspective where knowledge becomes more entrenched, 'making it harder to innovate in more creative or far-reaching ways' (Roberts & St John, 2022, p. 7).

At the system level, fragmentation can have disintegrative effects (Beckfield, 2008, p. 421). Disjointed clusters of homogeneous actors reduce the capacity of governance systems to adapt to changing circumstances and remain resilient in times of crises (Duit *et al.*, 2010; Keohane & Victor, 2011). Fragmentation also favours powerful actors, who may be the only ones capable of reaching multiple clusters and exerting influence over a governance system, despite high transaction costs (Drezner, 2009; Morrison *et al.*, 2019).

However, fragmentation into homogeneous clusters is not a fatality. Not all governance systems become continuously more fragmented. Greenhill and Lupu (2017) analysed changes in the network of international organisations and found that it has become less fragmented in recent decades. Similarly, Kim (2013) found that the network of multilateral environmental agreements has 'defragmented' since 1976. Some authors suggested that global governance systems tend to oscillate in non-linear ways between fragmentation and contraction (Gomez & Parigi, 2015), or between specialisation and integration (Morin & Orsini, 2014).

How can we then explain that global governance systems with homophilic tendencies find this balance instead of fully fragmenting over time? Abbott and Faude (2022, p. 281) suggested three mechanisms through which institutional designers can manage heterogeneous governance systems: institutional design for complementarity, decentralised adaptation, and strategic ordering. Each explanation focuses on how institutional designers attempt to bring cohesion to a governance system by fostering specialisation when creating new institutions, when adapting existing institutions over time, or when influencing the design of other institutions. Crucially, their focus is on how institutional designers *purposively* attempt to manage heterogeneity by changing their institutional roles and activities, or orchestrating interactions among institutions to achieve a specific goal (Abbott *et al.*, 2015). In other words, they look at how changes at the level of single institutions can intentionally contribute to bringing coherence at the governance system level. Roberts and St. John (2022) similarly highlight the purposive role institutional actors can play in shaping and 'gardening' the evolution of governance systems.

Building on recent applications of complexity ideas in global governance (Orsini *et al.*, 2020; Winston, 2023), we instead consider how governance systems can remain cohesive through decentralised cooperation. We here understand decentralised cooperation as a process through which institutional actors establish relations among themselves and shape the structure

of governance systems without central coordination. Next to changes at the individual or institutional level, complexity scholars emphasize that interactions among system units can have system-wide effects, such as self-organisation and adaptation at the system level (Mitchell, 2009). Various studies in global governance, for example, show how different regimes evolved relatively coherently from the uncoordinated interactions among their individual institutions (Morin, Pauwelyn *et al.*, 2017; Pauwelyn, 2014). These studies, however, focus on systems composed of relatively homogenous actors and institutions and do not explain how complex properties can emerge despite homophilic tendencies pushing toward fragmentation.

Hybridity, bridging ties and brokerage

In this paper, we argue that hybrid organisations are well-positioned to create bridges between different organisational forms. It is important to note that we hereafter use the term 'hybrid' to describe certain organisational actors (Schemeil, 2013). This differs from Williamson's interest in hybrid arrangements, 'located between market and hierarchy' (1991, p. 283),[8] or Hoeffler's work on hybrid policies, combining 'regulatory and capacity-building instruments' (2023, p. 1288). It also contrasts with Abbott and Faude, who study 'hybrid institutional complexes' (2022), defined as governance systems made of various types of actors and arrangements. While we acknowledge that arrangements and entire governance systems can be conceptualised as 'hybrids', we hereafter focus on hybrid organisational actors.

Organisations can be hybrids in different ways. In line with our definition of homophily as relations between organisations sharing similar organisational form, we understand hybrid organisational actors as actors combining attributes of more than one organisational form. In that respect, the most extensively studied types are those that combine attributes of two of the three main organisational forms of the 'governance triangle': governments, firms, and NGOs (Abbott & Snidal, 2009). For example, social enterprises combine elements of NGOs and firms; state-owned enterprises combine elements of governments and firms; and some certification organisations combine elements of NGOs and governments (Doherty *et al.*, 2014; Haigh *et al.*, 2015). Other forms of hybridity are also possible. Morin, Louafi *et al.*, (2017) study hybrid organisations that are partly political and partly scientific, such as the Intergovernmental Panel on Climate Change. Murdie and Davis (2012) classify as hybrid organisations NGOs that perform both public advocacy and stakeholder services, as well as NGOs that operate across multiple issue-areas.

The organisational ecology literature highlights how specific organisational forms tend to replicate themselves once they achieve legitimacy (Hannan & Freeman, 1977; Carroll, 1984). Rather than trying to invent new

organisational forms, most organisations will find it easier to replicate existing models (Beaumier *et al.*, 2023). Yet, hybrid organisations are relatively common in global governance, even if often unrecognised. For Bruno Latour, one feature of modernity is futile attempts to 'purify hybrids' by creating clear categories (2012). However, as societies strive to achieve modernity and the world becomes more complex, hybrids paradoxically multiply. This led Latour to conclude that 'we have never been modern' (2012). Aside from organisations representing pure ideal types, many others combine attributes from different organisational forms.

Because hybrid organisations share attributes with multiple organisations, they are less prone to strict homophily. They can conclude arrangements at low transaction costs, not only with other hybrids but also with different organisations with whom they share some characteristics (Murdie & Davis, 2012). Therefore, hybrids can more easily connect clusters than other organisations. In network parlance, they can fill 'structural holes' (Burt, 2004) and create 'weak ties' (Granovetter, 1973) between distant clusters. Hybrids are not the only organisations with the capacity to build these bridges, but it is easier for them than for others, other things being equal.

Once these bridges are established, hybrid organisations can act as brokers (Burt, 2004). We understand brokers as actors creating and exploiting bridging ties. Bridging refers to ties connecting two clusters of organisations, and brokerage involves exploiting these ties to shape resource distribution in a system (Everett & Valente, 2016, p. 202). By acting as brokers, hybrid organisations gain valuable competitive advantages. Previous studies found evidence that brokers can gain additional information (Burt, 2004, 2005), diffuse ideas (Seabrooke & Tsingou, 2014), and influence resource-sharing among different clusters of organisations (Bidwell & Fernandez-Mateo, 2010).[9] Therefore, it is in hybrids best interest to create and sustain bridges.

Hybrid organisations do not necessarily aim to perform orchestrating functions. Their effect on the system might be unintentional. Even when hybrid organisations don't aim to minimise fragmentation in their governance system, their creation of bridging ties and brokerage activities help hold their governance system together. They facilitate the diffusion of ideational and material resources, offsetting homophilic tendencies in expanding governance systems. As 'hybrid' and 'pure' organisations conclude institutional arrangements, they contribute to the self-organised order of complex governance systems (Kauffman, 1993). Even when no single organisation orchestrates the governance system structure, the work of hybrid organisations ensures that it remains relatively cohesive and avoids excessive fragmentation.

This paper illustrates this theoretical argument by examining the role of the European Space Agency (ESA) in mitigating fragmentation within the space governance system. Before focusing on the ESA, the next sections

provide a detailed overview of the space governance system and its expansion in terms of size and diversity over time.

Case and methods: the space governance system

In this study, we combine two datasets to analyse the evolution of the space governance system structure and the role of ESA in it.[10] The first dataset comprises a comprehensive list of every public and private organisation involved in satellite-related activities. It covers states, national agencies, international organisations, for-profit, non-profit, and universities. The second dataset provides an exhaustive collection of institutional arrangements signed among these organisations, including treaties, contracts, certifications, memorandums of understanding, and group guidelines (Morin & Tepper, 2023).

We use these datasets to build the network of international bilateral arrangements signed among space organisations between 1960 and 2019.[11] It is frequent in network analyses applied to global governance to focus solely on bilateral arrangements (see e.g., Cranmer *et al.*, 2014; Goyal & Joshi, 2006; Oatley *et al.*, 2013). While bilateral arrangements are dyadic partnerships through which two actors exchange specific resources, such as information or specific space capacities (Borowitz, 2022), multilateral arrangements involving multiple actors generally aim to set broad principles in a given governance system (Hollway & Koskinen, 2016, p. 282). As this paper aims to understand how homophilic tendencies shape the distribution of resources in governance systems, we focus on the network of international bilateral arrangements signed in space governance.

We take the signature of one arrangement as the indicator that an organisation joined the network. We avoid using an organisation's founding year as many only start performing space activities years later. We further assume that every arrangement represents an opportunity for cooperation and resource exchange without giving weight to their interaction. Additionally, we limit ourselves to arrangements signed among organisations headquartered in different countries to observe how the space governance system evolves at the global level. This also allows us to control for the homophilic tendency of organisations to collaborate with their national counterparts. For example, NASA is more likely to sign arrangements with American organisations (public and private) than with organisations based in other countries.

According to our data, 240 space organisations signed 1189 international bilateral arrangements between 1960 and 2019. Figure 1 illustrates the cumulative number of organisations that have signed at least one international bilateral arrangement and the cumulative sum of arrangements they signed over that 60-year period. The figure highlights how the space governance system moved from a dozen states signing treaties to hundreds of organisations linked through a growing web of heterogeneous

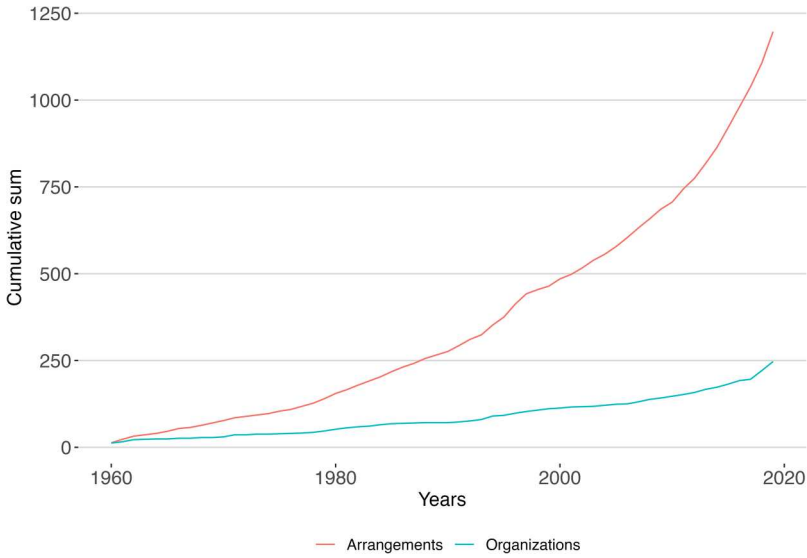

Figure 1. Evolution in the cumulative number of space organisations and international bilateral arrangements (1960–2019).

arrangements, in line with previous contributions (Jakhu & Pelton, 2017; Quintana, 2017). The exponential growth of arrangements suggests a trend toward increased connectivity among space organisations over time. Today, the average space organisation has at least one bilateral arrangement with 4–5 foreign organisations compared to 2 at the end of the 1960s. However, the overall system did not become denser, partly because many organisations signed multiple arrangements with the same counterparts. We return to this point in the next section when discussing the effects of homophily and the evolution of the network structure in greater detail.

Our two datasets show that, in addition to growing in size, the space governance system has significantly diversified over time. In the 1960s, only a select group of states and their national agencies accounted for all international arrangements, representing 20 countries. By 2019, our data reveals that, in addition to national governments and specialised agencies, 11 intergovernmental organisations and 36 private organisations have signed at least one international bilateral arrangement. Moreover, space organisations now represent around 100 countries and exhibit greater variation in their budget and number of employees, contributing further to the overall heterogeneity of the bilateral network of space arrangements.

In the last section, we supplement our network analysis with interview data to describe ES's brokerage and how it contributed to promoting cohesion in the expanding and diverse space governance system. We conducted 52 semi-structured interviews between August 2021 and August 2022,

reaching out to each participant through their publicly available professional email address.[12] All interviews were conducted online and lasted approximately 45 min. Interview notes, or transcripts when the interviewee agreed to audio recording, were then transformed into thematic summaries. Interviewees are from 21 countries across all continents, including 24 CEOs or senior staff of private organisations, 11 heads of section or senior representatives of IGOs, and 10 senior directors or staff of national space agencies.[13] In the next section, we first demonstrate through our network analysis how the space governance system displays characteristics of complex systems, despite space organisations' homophilic tendencies.

Homophily and complexity in space governance

In recent years, various studies described space governance as fragmented (Jakhu & Pelton, 2017) and complex (Migaud *et al.*, 2021). As Kim (2020, p. 906) pointedly notes, both concepts describe systems with multiple interrelated units without clear relations of authority. Where they crucially differ is in how their units connect. Fully fragmented systems tend to be very loosely connected, making any exchanges of resources among them hard (Biermann *et al.*, 2009, p. 20). Meanwhile, complex systems evolve between fragmentation and unity. Despite lacking a single centre, they remain sufficiently well-tied together to enable information and resource sharing across multiple communities of actors. In contrast to fully connected systems, not all actors are, however, equally close to each other. The combination of a relatively high level of connectedness with strong differentiations among individual units is crucially what supports emergent properties, such as self-organisation and adaptation (Orsini *et al.*, 2020, p. 1011).

Based on network theory, Kim (2020, p. 919) suggests seven measures to differentiate fragmented and complex systems: clustering coefficient,[14] modularity,[15] centralisation,[16] density,[17] average path length,[18] skewness,[19] and fraction of the giant component.[20] We use each of these measures to assess to what extent the space governance system evolved as a complex system considering homophilic tendencies.

Governance systems moving toward greater fragmentation should have higher modularity, average path length, and smaller size of the fraction of the giant component, all tendencies exacerbated by organisations' homophilic preferences. Organisations' preferences to sign arrangements with similar partners should foster small communities of closely tied organisations loosely connected to each other as the system grows in diversity. In turn, this should lead organisations to collaborate with the same partners over time, resulting in lower network centralisation and density.

Meanwhile, governance systems evolving as complex systems should oscillate between fragmentation and unity. They should exhibit higher

clustering coefficients and lower average path lengths. Actors in a complex system should tend to connect to the same actors their partners connect with while remaining relatively close to everyone in the system. These two tendencies can co-exist due to a few highly connected actors, resulting in higher skewness in node centrality over time. These highly connected actors counterbalance homophilic tendencies by creating connections between different groups of actors, translating into a higher fraction of the giant component.

Based on the analysis of arrangements signed among space organisations, we find evidence of a strong homophilic tendency among space organisations.[21] Between 1960 and 2019, the overall share of arrangements signed among organisations of the same type is constantly higher than 90 per cent.[22] This tendency is largely driven by the fact that states tend to sign arrangements with other states, and national agencies with other national agencies, since these two types of organisations account for the majority of bilateral international arrangements.

Moreover, most bilateral arrangements are between organisations from similar income groups. While down from 70 per cent in the 1960s, 60 per cent of arrangements signed in the last decade were still among organisations from the same income group, per World Bank data. Strikingly, many organisations from low- or middle-income countries tend to sign bilateral arrangements with other developing countries. As of 2019, 55 per cent of arrangements involving organisations from these countries were with other organisations from the same income group. This relatively high share of arrangements signed among themselves is significant since many have relatively few space capacities and resources to share compared to organisations from more affluent countries, indicating a strong homophilic tendency.

We can finally observe homophily in organisations' preference to cooperate with others performing similar activities to them. For example, according to our dataset, the European Organisation for the Exploitation of meteorological satellites (EUMETSAT) exclusively signed arrangements with other meteorological organisations. Similarly, 80 per cent of all arrangements signed by NASA with non-US partners are with other space agencies.

Despite these homophilic tendencies pushing toward fragmentation, we simultaneously find that the global space governance system oscillated toward more unity and structurally grew to reflect a complex system. Table 1 presents the evolution of the network structure at the end of each decade since 1969, using the indicators introduced above.[23] On the one hand, it shows that the global space governance system became progressively less dense, less centralised, and more modular, all signs of fragmented systems. On the other hand, the decrease in average path length and constantly high fraction of the giant component points to a governance system becoming more united over time.

Table 1. Evolution of the global bilateral network structure by decade (1960s–2010s).

	1969	1979	1989	1999	2009	2019
Clustering coefficient	0.111	0.140	0.104	0.118	0.153	0.150
Modularity	0.260	0.338	0.409	0.440	0.461	0.450
Centralisation	0.567	0.401	0.377	0.505	0.438	0.308
Density	0.100	0.064	0.047	0.033	0.029	0.019
Average path length	8.447	5.475	5.138	4.360	4.105	3.877
Skewness	3.457	3.120	3.731	5.625	5.306	4.824
Fraction of the giant component	1	1	1	0.963	0.920	0.975

A visualisation of each network is available in Figure 3.

Moreover, the increase in node centrality skewness suggests unity comes from a few highly connected organisations. For comparison purposes, a random network generated with the same number of organisations and links as of 2019 has a skewness value of 0.4, where 0 would indicate that all organisations have the same number of connections. According to our dataset, the two most connected organisations, NASA and ESA, have signed at least one international bilateral arrangement with 248 and 258 organisations, respectively. The number of bilateral partners of the third-most connected organisations drops to 180 and below 50 for those outside the top 10. Figure 2 shows the skewed distribution in the number of partners for the top 50 most well-connected organisations.

The oscillation of the global space governance system between fragmentation and unity reflects its tendency to evolve as a complex system. Despite the growth in the diversity of space actors and their homophilic preferences,

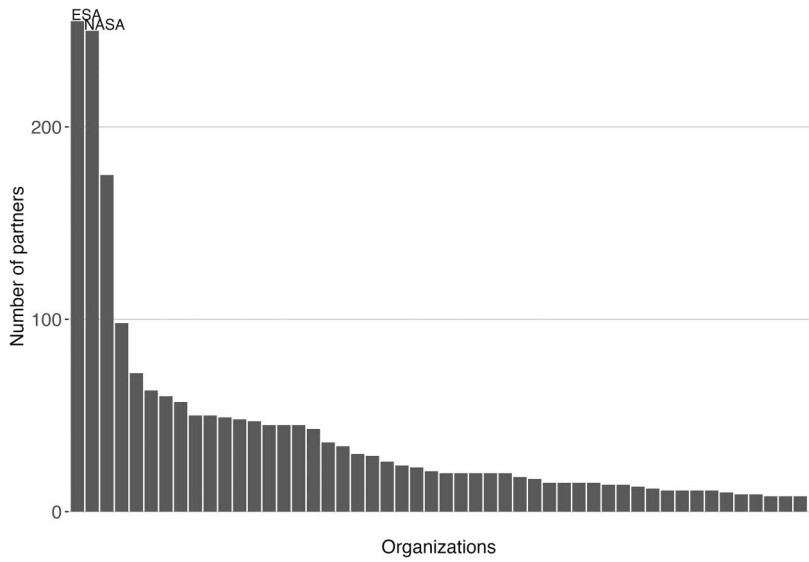

Figure 2. Distribution in the number of bilateral partners for the top 50 most well-connected organisations from 1960 to 2019.

the overall system remained relatively united over the years due to few central organisations bridging the different communities of space actors. In the next section, we highlight the special role played by ESA, as a hybrid organisation, in keeping the space governance system cohesive.

The cohesive role of the European Space Agency

ESA's multidimensional hybridity

Formally speaking, ESA is an archetypal regional intergovernmental organisation. Created in 1975 from the merger of the European Space Research Organisation (ESRO) and European Launcher Development Organisation (ELDO), it coordinates the space activities of 22 European Member States, four Associate Members, and five Cooperating States, including Canada outside Europe. It has institutionalised coordination, dispute settlement, funding, and voting procedures.

At the same time, ESA differs from other regional intergovernmental organisations. More than simply promoting cooperation among its Member States, it works to develop global space activities just like other national space agencies. For instance, ESA co-founded the Inter-Agency Space Debris Coordination Committee (IADC), participates in multilateral institutions like the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS), and collaborates on several other international projects (Cross, 2021; ESA, 2023a). ESA is also a signatory to the International Space Station with space agencies from the United States, Russia, Canada, and Japan. It is not surprising, then, that besides being a regional intergovernmental organisation, many interviewees described ESA as having a 'peer-to-peer' or 'horizontal' relationship with national space agencies (Interviews 3; 13; 16; 22; 25; 27; 32; 39; 41; 51).

In fact, ESA, 'as a space agency, is conducting programmes on behalf of its Member States' (Interview 25). While some European countries have their own national space agencies and programmes, others have less institutionalised domestic structures for space activities (Sagath *et al.*, 2019). Senior staff from two newer or smaller space-faring Member States explained that ESA acts as their *de facto* space agency as their respective states lack the resources to maintain a space programme alone (Interviews 3; 46).

ESA's hybridity also comes from its peculiar function as a European industrial policy actor. One of its core missions, inherited from its predecessor ELDO, is the promotion of the European space industry competitiveness. Over the years, it launched several programmes to support its emergence, including establishing a new European Centre for Space Economy and Commerce (ESA, 2023c). ESA also promotes the development

of each of its Member States' space industry through its policy of *juste retour*, which requires the organisation to distribute contracts proportionally to each Member State's financial contributions. While this policy was criticised for favouring Member States with higher funding capacities (Hörber, 2015), it ensures that Member States with limited space capacities receive a return on their investment that benefits their industry (Brandenburg & Hoerber, 2020). It also allows companies from Cooperating States, such as Canada, to benefit from preferential consideration in ESA's allocation of contracts.

ESA's institutional requirements to contract out the execution of its various projects is notably why it has significantly fewer employees than NASA (Brandenburg & Hoerber, 2020). At the time of writing, it is one of the main contract providers in Europe, as recognised by many interviewees (Interviews 11; 18; 21; 25; 27; 46). Undertaking this role is significant in a context where developing an industrial policy has been a longstanding challenge for the European Union, which is commonly seen as a regulatory power (McNamara, 2023).

In sum, ESA surpasses the typical goals of regional intergovernmental organisations for cooperation and shares characteristics and functions with other types of organisations. While other space organisations may have some hybrid elements, ESA's multidimensional hybridity sets it apart, allowing it to overcome strict homophily tendencies and create bridges across diverse actors.

ESA's arrangements as bridges

As a hybrid organisation, ESA tends to form partnerships with a broader range of organisations than typical space organisations. Figure 3 illustrates the evolution of the space governance system structure and ESA's position over time (highlighted in red with its arrangements). We can observe how ESA gradually positioned itself at the centre of the system structure by signing arrangements with a diverse range of partners. In addition to connecting the two largest communities of space organisations in numerical terms (i.e., states and national space agencies), ESA also created connections with other intergovernmental organisations and various types of private space entities.

Through the signature of these various arrangements, ESA has become the most central space organisation. Figure 4 plots each space organisation according to their betweenness and eigenvector centralities as of 2019. The former calculates the extent to which an actor is positioned on the shortest path between two others,[24] while the latter measures the degree to which an actor has connections with other central actors.[25] We use a measure of betweenness to evaluate space organisations' positions as a bridge in the global space governance system instead of Gould and Fernandez's (1989)

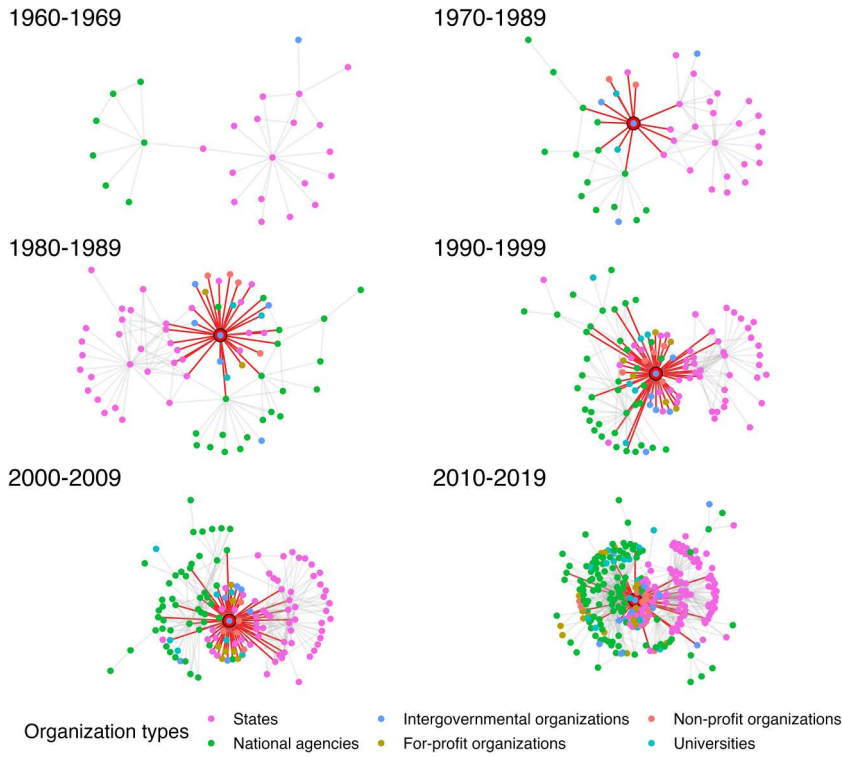

Figure 3. Evolution of network structure by decade (1960s–2010s).

Network visualisation created using the backbone layout algorithm in the igraph R package version 1.3.5. Each link indicates that two organisations from different countries share at least one bilateral arrangement. Each node represents an organisation with at least one bilateral arrangement. Two small disconnected components were excluded for visualisation purposes.

measure of brokerage activity to account for the indirect brokering effects of ESA arrangements. Gould and Fernandez's measure calculates the number of instances an actor sits between two others, while betweenness gives a more structural measure of the tendency of an actor to be between multiple and potentially distant actors. As discussed below, we believe the brokerage activities we describe can have effects outreaching a given interaction.

Apart from NASA, no other space organisations come close to ESA's centrality. National governments and agencies from other leading space countries make up the second tier of central organisations, including the Canadian Space Agency (ASC-CSA), the Russian Federation Space Agency (RFSA), Indian Space Research Organization (ISRO), and Centre National d'Études Spatiales (CNES). None of these organisations are, however, near ESA or NASA. While some argued that intergovernmental organisations could support greater cohesion in global governance by orchestrating the activities of various types of actors (Abbott & Snidal, 2010), we strikingly

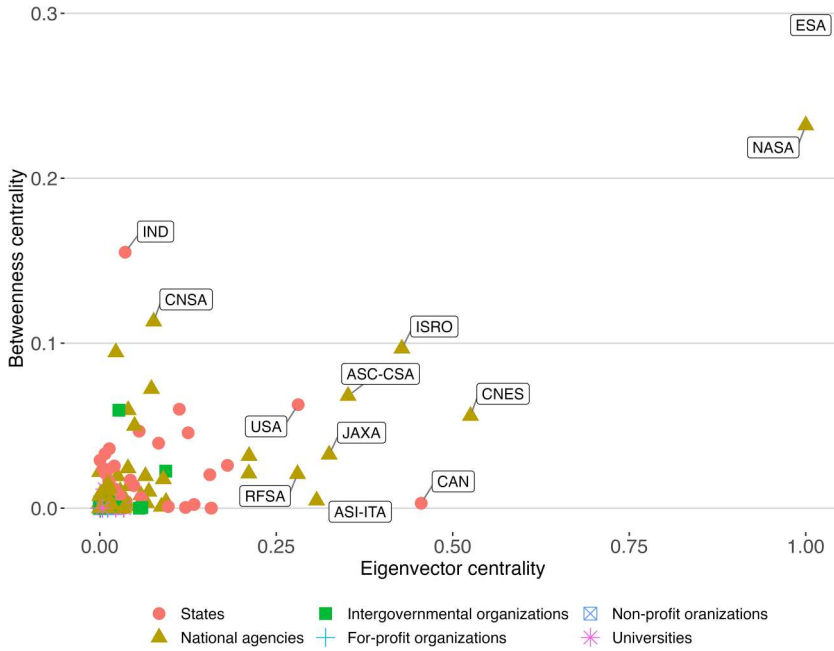

Figure 4. Betweenness and eigenvector centralities of space organisations in 2019.

find that most of them remain on the margins of the space governance system structure. This reflects the comparatively small number of intergovernmental organisations and their tendency to collaborate with each other. Private organisations (for-profit, non-profit, and universities) are finally grouped in the bottom left corner and almost impossible to see. Despite recent studies pointing out the significant growth in the importance of private space organisations (Denis *et al.*, 2020), our data show that they remain marginal actors in the network of international bilateral arrangements signed with other space organisations.

The high eigenvector centralities of both ESA and NASA demonstrate their tendency to collaborate closely as the two most central space organisations. Over the years, they signed 40 arrangements on a range of issues, including joint space missions, satellite launches, and information sharing. The main difference between ESA and NASA is the former has a significantly higher betweenness centrality (43 per cent higher) than the latter.[26] The higher betweenness centrality score reflects ESA's tendency to bridge different groups of actors. Specifically, NASA signs 80 per cent of its arrangements with other space agencies and another 15 per cent with ESA. Only 5 per cent are with other types of organisations. While previous research found that NASA increasingly collaborates with industry actors in the United States (Mazzucato & Robinson, 2018, pp. 170–171), our findings show that it follows stricter

homophily tendencies on the global stage through its signature of bilateral arrangements. Meanwhile, as a hybrid organisation, ESA signed 63 per cent of its arrangements with space agencies, 20 per cent with states, 11 per cent with international organisations, and 6 per cent with private organisations. To put it differently, 59 per cent of all pairs of organisations connected by ESA involved organisations of different types (e.g., a space agency and a national government). Meanwhile, only 7 per cent of pairs connected by NASA represented two different types of actors.

ESA achieved this unmatched centrality in space governance, despite not being the wealthiest or most prestigious organisation in space governance. While not trivial, ESA's budget is significantly smaller than NASA. In 2022, ESA spent 7.15 billion Euros (ESA, 2022) compared to 29.2 billion US dollars by NASA (USAspending.gov, 2022). It is also smaller than China's space agency budget, which experts estimated to be over 8 billion USD in 2019 (Campbell, 2019). Other space agencies in notably Japan and France also have billion-dollar budgets without having close to the same centrality as ESA. This is without considering military organisations or private space companies boasting billion dollars budget. In addition to not being the wealthiest organisation, ESA lacks the prestige of some of its counterparts, and chiefly NASA. As of writing, it is still working to launch its first successful moon mission and establish Galileo, its competitor to NASA's Global Positioning System (GPS). It also does not launch close to as many rockets as Space X. In recent years, space agencies of other space-faring nations, such as China and India, have also achieved significant milestones in their space programmes, rivalling ESA's accomplishments, each notably landing a spacecraft on the moon.

More than ESA's material or ideational resources, even though significant compared to many others, its hybrid nature is what differentiates it from NASA and other important space organisations. Its peculiar nature as an international organisation, a space agency and an industrial policy actor helped it establish itself as a crucial broker in space governance.

ESA's brokerage role

Strong from its hybrid characteristics and the bridges they facilitate with different clusters of homogenous organisations, ESA has been able to capitalise on its position and act as a broker in the space ecosystem.

As an IGO chiefly created to promote cooperation in Europe, ESA notably formed partnerships with the European Union to exchange various resources. Over the years, the Council of the European Union and the ESA Council of Ministers held several meetings to strengthen and deepen their cooperation (Cross, 2021). They formalised their close relationship through a Framework Agreement adopted in 2004 (ESA, 2023a). In 2016, ESA and the European Commission signed a Joint Statement reaffirming their shared vision and

goals and emphasizing their desire to reinforce their cooperation in the future (ESA, 2023a). At the time of writing, a quarter of ESA's funding comes from European sources (ESA, 2022), making it the main institution implementing the European Union's space programme.

ESA also serves as a broker between its Member States' space agencies. A senior staff member from one of Europe's oldest space agencies noted that ESA ensures 'everyone work[s] in the same direction to try to solve a key problem' (Interview 7). Another senior staff from a newer ESA Member State explained that within ESA, 'States try not to compete, but pull their resources, their strong points together, to be complementary and to develop bigger projects, bigger ideas, and to contribute to the European space ecosystem and capacity building' (Interview 46). Especially for its smaller and newer spacefaring members, ESA acts as a bridge between them, other European agencies, and the space community. The same interviewee provided a striking example of this international public brokerage when asked if they worked with both the United States and China, and they explained that they are only able to engage in projects uniting both 'under ESA's framework'. Another senior staff of a smaller European space agency underlined that they could only take part in international projects and discussions through their ESA membership, going as far as saying that 'without ESA, it would not make sense for [them] to be in the space community' (Interview 3).

It is as an industrial policy actor that ESA takes on an even more special brokerage role among its Member States. While national agencies tend to prioritise their domestic industries, ESA fosters relationships between public and private organisations from different Member States. Its *juste retour* policy connects all Members' public resources and industries as it pools financial resources from bigger and smaller Member States, Associate Members, and Cooperating States. It then redistributes the pooled resources among all their private companies. Larger states are encouraged to invest more to favour their industry. Meanwhile, smaller ones can maximise their impact by joining major space projects, which they could not realise alone (Brandenburg & Hoerber, 2020). ESA also calls on its Member States to allow companies from other to participate in their national space projects, supporting further brokerage among the space industries of all its Member States. Depending on their specific agreement, companies from Associate Members or Cooperating States can also benefit from these pooled resources and increased access to other countries' procurement for space projects. In sum, the signature of accession or cooperation agreements with ESA creates significant bridges and opportunities between industry players and national government organisations of different countries and sizes.

Interestingly, this brokerage role extends beyond countries formally associated with ESA. ESA's major space missions, research, and development initiatives also help catalyse collaborations between industry players,

research institutions, and public agencies from non-affiliated countries. Several interviewees from the United States and Latin American countries mentioned having participated as subcontractors in ESA's projects (Interviews 9; 13; 31; 51). ESA's brokerage fosters partnerships between foreign public and private actors, which tend to last and be recreated in other contexts (Feyerer, 2015). As one of Europe's leading space firms' senior staff explained, their involvement in ESA's projects enables them to create networks of partners that they later reuse in other projects (Interview 27). They and another interviewee also explained that while industry players are generally in competition, they often see more benefits in collaborating in the context of ESA's large projects (Interview 11; 27).

As another interviewee noted, ESA opens the door for 'cooperation and various agreements' with other organisations (Interview 3). ESA's involvement in the International Space Station (ISS) notably created bridges between European and non-European companies by allowing them to become contractors or subcontractors. As of 2023, around 300 European private organisations were involved in the ISS because of their work with ESA (ESA, 2023b). This in turn opened new business opportunities for these European companies, notably as part of the Orion project. This initiative builds on NASA and ESA cooperation in the ISS, allowing companies across Europe to provide parts for the Orion spacecraft built by Airbus Defence for the NASA-led Artemis programme (NASA – Glenn Research Center, 2021).

ESA's international brokerage contrasts sharply with NASA. While also a major industrial player, NASA primarily contracts with American companies and does not link foreign organisations to the same degree as ESA (Brandenburg & Hoerber, 2020). Many interviewees maintained that national requirements for private entities to bid on American federal projects are significant hurdles for them working with NASA (Interviews 2; 4; 8; 10; 16; 18; 21; 24; 43). Some even mentioned opening distinct branches in the United States to bid on public contracts there (Interviews 13; 23; 27). It differs significantly from ESA's industrial policies that, while prioritising companies from its Member States, are more open to creating partnerships and pooling resources from multiple countries.

Lastly, as a broker, ESA plays an increasingly important role in the diffusion of standards for space activities. While not formally a standardisation organisation, 'ESA is very strong in setting up technical standards for space activities' (Interview 25). In the context of its projects and through the work of its engineering branch, ESA regularly' 'co-develops' technical requirements with industrial players. ESA benefits from its position when devising standards by gaining input and information from the wide variety of actors involved in its projects, whether it is the policy experience of older space agencies or the technical developments of established industry players. These standards are then re-used in other ESA and non-ESA projects as its contractors and

subcontractors embed them in their practices. On the private side, ESA's position as one of the prime contract providers in the space sector lead its requirements and standards to diffuse to industry organisations worldwide, making it a *de facto* central standard-setting organisation in space governance (Interviews 4; 11; 25; 27; 35; 46; 51). One interviewee, for example, emphasized that requirements included in ESA's programmes 'feed into the EU, along with other organisations, that end up helping to form standards and regulations' (Interview 35). Another interviewee added that these standards are then incorporated by its Member States as they face a situation akin to 'peer pressure' where no country wants to be the 'bad guy' or the one lacking behind in terms of regulation (Interview 46). They also allow cost-reduction in the production of regulations for smaller Member States that 'are too small to have separate […] regulations or laws' and prefer applying ESA's regulation as it has 'the technical competence, which smaller states don't have in this specific […] depth' (Interview 3).

In sum, ESA contributed to the cohesion of the space governance system through its ability to establish bridging ties and perform brokerage between different actors. Without ESA's involvement, all other things being equal, the global space governance system would be more fragmented, with many organisations lacking any connections between them. This would limit their capacity to adapt and launch large-scale projects by constraining their capacity to exchange financial resources and share expertise. This would also tend to produce more groupthink, which, in turn, could impede the creation and diffusion of new policies and standards. Conversely, if every organisation acted like ESA, the space governance system would be significantly denser, potentially leading to an overload of collaborations and partnerships. ESA's role as a broker strikes a delicate balance between creating ties and avoiding excessive density, resulting in a more cohesive yet adaptable space governance system (Beaumier *et al.*, 2023; Roberts & St John, 2022).

Conclusion

Over the past six decades, the space governance system has grown substantially in size and diversity. Besides governments and public agencies from historically prominent space-faring countries, public and private organisations from over a hundred countries are now actively involved in space governance through the conclusion of international arrangements, supporting information and resource sharing while also contributing to setting new standards and rules in space.

We find space organisations tend to partner with others sharing similar traits. Governments work with other governments, space agencies with space agencies, and private organisations with private organisations. Due to this homophilic tendency, we might have expected the space governance system

to become a collection of divided and loosely connected groups. However, space governance exhibits characteristics closer to a complex system where sub-groups remain tightly connected through a few key actors. ESA played a significant role in this outcome due to its hybrid nature, combining characteristics from intergovernmental organisations, space agencies, and industrial policy actors. This hybrid nature allowed ESA to create bridges among different types of organisations at relatively low transaction costs, accessing information, sharing ideas, and connecting otherwise separate entities.

Previous studies emphasize how individual actors can bring cohesion to governance systems through orchestration (Abbott & Faude, 2022) or adaptive design (Roberts & St John, 2022). While acknowledging that no individual actor fully controls the evolution of governance systems, they argue that cohesion results from the purposive actions of a few key actors. We showcase how governance systems can also remain cohesive organically through the combined effects of individual homophilic preferences and the brokerage role of hybrid organisations. Our argument is not that hybrid organisations manage complex systems. Rather, the combination of organisations' homophilic preferences and a few hybrid organisations creating bridges among otherwise disconnected groups allows a governance system to remain relatively cohesive. This result contrasts with system structures that would emerge if each tendency operated alone: homophily would push toward a more fragmented system while bridging alone would lead to a denser and likely less adaptive system.

This research lays a foundation for future work to delve deeper into the nature, role, and origins of hybrid organisations. We focus on combining characteristics from different organisational types, but hybridity can arise from diverse sources, like organisational missions and locations. Further studies could explore hybridity variations across governance systems and the impact of these variations on brokerage activities. Identifying conditions fostering hybridity beyond European institutions (such as ESA) would also prove valuable. As growth, diversification, and homophilia appear common in many governance systems, yet seldom lead to dysfunctional fragmentation, we expect that hybrid organisations often play a key role in maintaining cohesion. However, this claim to generalisation remains to be tested. From the Internet Corporation for Assigned Names and Numbers (ICANN), a private company originally operating under a contract with the United States Department of Commerce in charge of assigning and managing Internet domain names and now operating with an international Governmental Advisory Board, to the International Seabed Authority, the intergovernmental organisation created to oversee deep sea mining activities with a private arm candidly named the Enterprise, international hybrid organisations exist in most, if not all, governance systems. Recognising and studying the role hybrids play in these different settings will enhance our understanding of cohesive and complex governance systems over time.

Notes

1. Preferential attachment, or the tendency to connect with the already well connected, is another well documented pattern in social network analysis.
2. This concept is similar to the concepts of 'global governance complex' (Eilstrup-Sangiovanni & Westerwinter, 2022) and 'Hybrid institutional complexes' (Abbott & Faude, 2022).
3. We hereafter prefer the term arrangements to agreements, traditionally equated to international treaties, to emphasize the diversity of institutional ties among global governance actors.
4. Recent exceptions include the literature on organisational ecology looking at how different 'populations' of global governance organisations interact with each other (Abbott *et al.*, 2016; Green & Hadden, 2021; Lake, 2021; Morin, 2020) and works on transnational public private partnerships (Borzel & Risse, 2005; Westerwinter, 2021).
5. Homophily can be measured in various ways (similarity in social relations, proximity, etc.). For this study, we limit ourselves to assortativity, i.e., similarity in actors' attributes.
6. Looking at international cooperation among states, Kinne (2013) finds that states sharing similar traits (e.g., political regime, military capability, economic development) increase their likelihood to cooperate in various issue-areas. Similarly, Maoz (2012) shows that democracies tend to form military alliances with other democracies and autocracies with other autocracies.
7. Clark (2021) finds that IGOs whose principals are geopolitically aligned tend to go beyond coordinating themselves and pooling financial and informational resources together. As their staff becomes socialised to their principals' similar preferences and the risk of cooperation failure diminishes, IGOs become more likely to achieve deeper cooperation (Clark, 2021, 1138–1139).
8. Hybrid arrangements include long-term contracting, private regulation, franchising, reciprocal trading. Fioretos (2021) discusses hybrid arrangements in global governance.
9. However, we do not make assumptions on the relative performance of hybrid organisations compared to non-hybrid organisations.
10. Information on the creation of the two datasets is available at www.institutions.space.
11. For other efforts to map the network of space actors, see Borowitz (2022), Pomeroy (2019) or Del Canto Viterale (2023)
12. This research received ethics clearance from the Ethics committee (Approbation #2020-283).
13. See the supplementary material for an anonymised list of the interviews.
14. The clustering coefficient represents the ratio of connected triangles in a network, ranging from 0 to 1. A higher clustering coefficient indicates that actors are more likely to connect with actors that share a connection with another one they are already connected with.
15. The modularity calculates the extent to which actors in a community have connections with actors from outside. It ranges from 0 to 1. A score of 1 would mean that actors in a community only have connections to each other.
16. Centralisation reflects the sum of differences between the actor with the highest degree centrality (i.e., the number of connections) and all other

actors' degree centrality divided by the maximum theoretical score. A high centralisation score describes networks with few highly central actors.

17. The density calculates the ratio of existing links over the total number of potential links. A low score indicates that a network is loosely connected, and a high score indicates that almost all actors share a connection.
18. The average path length measures how many links two actors must cross to reach each other on average. A low score means that actors only have a few connections between each other.
19. Skewness measures the extent of departure from a normal distribution of degree centrality measures. In this case, it reflects the D'Agostino Test value of the distribution. A score below −1 indicates a significantly left-skewed distribution (i.e., toward low degree centrality values), and a score higher than 1 indicates a significantly right-skewed distribution (i.e., toward high degree centrality values).
20. The fraction of the giant component measures the ratio of actors connected to the biggest network component over the total number of actors in the network. A score of 0 means no actors share a connection, while 1 means all actors are connected to the main network component.
21. We exclude the European Space Agency from our calculus of homogeneity statistics in line with our argument developed in the next section that it is a hybrid organisation.
22. If we were to include the European Space Agency as an intergovernmental organisation for this calculus, the share of homogenous arrangements would drop to 75 per cent. This simultaneously lower but still high homogeneity share reflects ESA's tendency to sign arrangements with more heterogeneous organisations while highlighting the prevalence of homophily.
23. We calculate each of these indicators using the igraph software package (Csardi & Nepusz, 2006).
24. Betweenness centrality reflects the normalised ratio of the sum of times an actor sits on the shortest path between every two pairs of nodes in the network.
25. Eigenvector centrality reflects an actor's centrality proportional to the sum of its connections' degree centralities.
26. We find similar results using Gould and Fernandez's measure, with ESA accounting for 35 per cent of all network brokerage activity and NASA only 14 per cent. We calculate this measure using the migraph software package (Hollway, 2021).

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References

Abbott, K. W., & Faude, B. (2022). Hybrid institutional complexes in global governance. *The Review of International Organizations*, *17*(2), 263–291. https://doi.org/10.1007/s11558-021-09431-3

Abbott, K. W., Green, J. F., & Keohane, R. O. (2016). Organizational ecology and institutional change in global governance. *International Organization*, *70*(2), 247–277. https://doi.org/10.1017/S0020818315000338

Abbott, K. W., Philipp, G., Duncan, S., & Bernhard, Z. (Eds.). (2015). *International organizations as orchestrators*. Cambridge.

Abbott, K. W., & Snidal, D. (2009). The governance triangle: Regulatory standards institutions and the shadow of the state. In W. Mattli, & N. Woods (Eds.), *The politics of global regulations* (pp. 44–88). Princeton University Press.

Abbott, K. W., & Snidal, D. (2010). International regulation without international government: Improving IO performance through orchestration. *The Review of International Organizations*, *5*(3), 315–344. https://doi.org/10.1007/s11558-010-9092-3

Abbott, K. W., & Snidal, D. (Eds.). (2021). *The spectrum of international institutions: An interdisciplinary collaboration on global governance*. Routledge.

AbouAssi, K., Wang, R., & Huang, K. (2021). Snuggling together or exploring options? A multilevel analysis of nonprofit partnership formation and evolution in an unstable institutional context. *Nonprofit and Voluntary Sector Quarterly*, *50*(1), 143–164. https://doi.org/10.1177/0899764020945800

Alter, K. J., & Meunier, S. (2009). The politics of international regime complexity. *Perspectives on Politics*, *7*(1), 13–24. https://doi.org/10.1017/S1537592709090033

Alter, K. J., & Raustiala, K. (2018). The rise of international regime complexity. *Annual Review of Law and Social Science*, *14*(1), 329–349. https://doi.org/10.1146/annurev-lawsocsci-101317-030830

Atouba, Y., & Shumate, M. (2010). Interorganizational networking patterns among development organizations. *Journal of Communication*, *60*(2), 293–317. https://doi.org/10.1111/j.1460-2466.2010.01483.x

Atouba, Y., & Shumate, M. (2015). International nonprofit collaboration: Examining the role of homophily. *Nonprofit and Voluntary Sector Quarterly*, *44*(3), 587–608. https://doi.org/10.1177/0899764014524991

Auld, G. (2014). *Constructing private governance: The rise and evolution of forest, coffee, and fisheries certification*. Yale University Press.

Beaumier, G., Papin, M., & Morin, J.-F. (2023). A combinatorial theory of institutional invention. *International Theory*, *16*(1), 50–76.

Beckfield, J. (2008). The dual world polity: Fragmentation and integration in the network of intergovernmental organizations. *Social Problems*, *55*(3), 419–442. https://doi.org/10.1525/sp.2008.55.3.419

Bidwell, M., & Fernandez-Mateo, I. (2010). Relationship duration and returns to brokerage in the staffing sector. *Organization Science*, *21*(6), 1141–1158. https://doi.org/10.1287/orsc.1090.0509

Biermann, F., Pattberg, P., Asselt, A. V., & Zelli, F. (2009). The fragmentation of global governance architectures: A framework for analysis. *Global Environmental Politics*, *9*(4), 14–40. https://doi.org/10.1162/glep.2009.9.4.14

Borowitz, M. (2022). Examining the growth of the global space situational awareness sector: A network analysis approach. *Space Policy*, *59*, 101444. https://doi.org/10.1016/j.spacepol.2021.101444

Börzel, T. A., & Risse, T. (2005). Public-private partnerships: Effective and legitimate tools of international governance. In E. Grande, & L. Pauly (Eds.), *Complex sovereignty: On the reconstitution of political authority in the 21st century* (pp. 195–216). University of Toronto Press.

Brandenburg, M., & Hoerber, T. (2020). Europe in space – the ESA's unique approach and vital contributions in comparison to NASA. In T. Hoerber, & A. Forganni (Eds.), *European integration and space policy* (pp. 119–136). Routledge.

Burt, R. S. (2004). Structural holes and good ideas. *American Journal of Sociology*, *110* (2), 349–399. https://doi.org/10.1086/421787

Burt, R. S. (2005). *Brokerage and closure: An introduction to social capital*. Oxford University Press.

Campbell, C. (2019). *From satellites to the moon and mars, China is quickly becoming a space superpower*. https://time.com/5623537/china-space/.

Carroll, G. R. (1984). Organizational ecology. *Annual Review of Sociology*, *10*(1), 71–93.

Cerny, P. G. (Ed.). (2022). *Heterarchy in world politics*. Taylor & Francis.

Clark, R. (2021). Pool or duel? Cooperation and competition among international organizations. *International Organization*, *75*(4), 1133–1153. https://doi.org/10.1017/S0020818321000229

Cranmer, S. J., Heinrich, T., & Desmarais, B. A. (2014). Reciprocity and the structural determinants of the international sanctions network. *Social Networks*, *36*, 5–22. https://doi.org/10.1016/j.socnet.2013.01.001

Cross, M. K. D. (2021). 'United space in Europe'? The European space agency and the EU space program. *European Foreign Affairs Review*, *26*(Special Issue), 31–46. https://doi.org/10.54648/EERR2021025

Csardi, G., & Nepusz, T. (2006). The igraph software package for complex network research. *InterJournal, Complex Systems*, *1695*(5), 1–9.

Currarini, S., Matheson, J., & Vega-Redondo, F. (2016). A simple model of homophily in social networks. *European Economic Review*, *90*, 18–39. https://doi.org/10.1016/j.euroecorev.2016.03.011

Del Canto Viterale, F. (2023). Transitioning to a new space age in the 21st century: A systemic-level approach. *Systems*, *11*(5), 232. https://doi.org/10.3390/systems11050232

Denis, G., Alary, D., Pasco, X., Pisot, N., Texier, D., & Toulza, S. (2020). From new space to big space: How commercial space dream is becoming a reality. *Acta Astronautica*, *166*, 431–443. https://doi.org/10.1016/j.actaastro.2019.08.031

Doherty, B., Haugh, H., & Lyon, F. (2014). Social enterprises as hybrid organizations: A review and research agenda. *International Journal of Management Reviews*, *16*(4), 417–436. https://doi.org/10.1111/ijmr.12028

Downie, C. (2022). Competition, cooperation, and adaptation: The organizational ecology of international organizations in global energy governance. *Review of International Studies*, *48*(2), 364–384. https://doi.org/10.1017/S0260210521000267

Drezner, D. W. (2009). The power and peril of international regime complexity. *Perspectives on Politics*, *7*(1), 65–70. https://doi.org/10.1017/S1537592709090100

Duit, A., Galaz, V., Eckerberg, K., & Ebbesson, J. (2010). Governance, complexity, and resilience. *Global Environmental Change*, *20*(3), 363–368. https://doi.org/10.1016/j.gloenvcha.2010.04.006

Eilstrup-Sangiovanni, M. (2016). Global governance networks. In J. N. Victor, A. H. Montgomery, & M. Lubell (Eds.), *The Oxford handbook of political networks* (pp. 689–714). Oxford University Press.

Eilstrup-Sangiovanni, M. (2020). Death of international organizations. The organizational ecology of intergovernmental organizations, 1815–2015. *The Review of International Organizations*, *15*(2), 339–370. https://doi.org/10.1007/s11558-018-9340-5

Eilstrup-Sangiovanni, M., & Westerwinter, O. (2022). The global governance complexity cube: Varieties of institutional complexity in global governance. *The Review of International Organizations*, *17*(2), 233–262. https://doi.org/10.1007/s11558-021-09449-7

ESA. (2022). *ESA budget 2022*. https://www.esa.int/ESA_Multimedia/Images/2022/01/ESA_budget_2022.

ESA. (2023a). *About us*. https://www.esa.int/About_Us/.

ESA. (2023b). *Companies involved with ISS*. https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/International_Space_Station/Companies_involved_with_ISS.

ESA. (2023c). *ESA space economy portal*. https://space-economy.esa.int/about-us.

Everett, M. G., & Valente, T. W. (2016). Bridging, brokerage and betweenness. *Social Networks*, *44*, 202–208. https://doi.org/10.1016/j.socnet.2015.09.001

Feyerer, J. (2015). Lessons from Galileo for future European public–private partnerships in the space sector. In T. C. Hörber, & P. Stephenson (Eds.), *European space policy* (pp. 211–223). Routledge.

Fioretos, O. (2021). Conclusion: Global governance and institutional diversity. In J. Pevehouse, K. Raustiala, & M. Barnett (Eds.), *Global governance in a world of change* (pp. 338–366). Cambridge University Press.

Gomez, C. J., & Parigi, P. (2015). The regionalization of intergovernmental organization networks: A non-linear process. *Social Networks*, *43*, 192–203. https://doi.org/10.1016/j.socnet.2015.03.007

Gould, R. V., & Fernandez, R. M. (1989). Structures of mediation: A formal approach to brokerage in transaction networks. *Sociological Methodology*, *19*, 89–126. https://doi.org/10.2307/270949

Goyal, S., & Joshi, S. (2006). Bilateralism and free trade. *International Economic Review*, *47*(3), 749–778. https://doi.org/10.1111/j.1468-2354.2006.00395.x

Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology*, *78* (6), 1360–1380. https://doi.org/10.1086/225469

Green, J. F., & Hadden, J. (2021). How did environmental governance become complex? Understanding mutualism between environmental NGOs and international organizations. *International Studies Review*, *23*(4), 1792–1812. https://doi.org/10.1093/isr/viab046

Greenhill, B., & Lupu, Y. (2017). Clubs of clubs: Fragmentation in the network of intergovernmental organizations. *International Studies Quarterly*, *61*(1), 181–195. https://doi.org/10.1093/isq/sqx001

Haigh, N., Walker, J., Bacq, S., & Kickul, J. (2015). Hybrid organizations: Origins, strategies, impacts, and implications. *California Management Review*, *57*(3), 5–12. https://doi.org/10.1525/cmr.2015.57.3.5

Hannan, M. T., & Freeman, J. (1977). The population ecology of organizations. *American Journal of Sociology*, *82*(5), 929–964.

Hoeffler, C. (2023). Beyond the regulatory state? The European defence fund and national military capacities. *Journal of European Public Policy*, *30*(7), 1281–1304. https://doi.org/10.1080/13501763.2023.2174581

Hofmann, S. (2019). The politics of overlapping organizations: Hostage-taking, forum-shopping and brokering. *Journal of European Public Policy*, *26*(6), 883–905. https://doi.org/10.1080/13501763.2018.1512644

Hollway, J. (2021). *migraph: Multimodal network analysis and more*. https://github.com/snlab-ch/migraph.

Hollway, J., & Koskinen, J. (2016). Multilevel embeddedness: The case of the global fisheries governance complex. *Social Networks*, *44*, 281–294. https://doi.org/10.1016/j.socnet.2015.03.001

Hörber, T. C. (2015). The European Space Agency and the European Union. In T. C. Hörber, & P. Stephenson (Eds.), *European space policy: European integration and the final frontier* (pp. 53–65). Routledge.

Jakhu, R. S., & Pelton, J. N. (Eds.). (2017). *Global space governance: An international study*. Springer.

Kauffman, S. A. (1993). *The origins of order: Self-organization and selection in evolution*. Oxford University Press.

Keohane, R. O., & Ostrom, E. (Eds.). (1994). *Local commons and global interdependence*. Sage.

Keohane, R. O., & Victor, D. G. (2011). The regime complex for climate change. *Perspectives on Politics*, *9*(1), 7–23. https://doi.org/10.1017/S1537592710004068

Kim, R. E. (2013). The emergent network structure of the multilateral environmental agreement system. *Global Environmental Change*, *23*(5), 980–991. https://doi.org/10.1016/j.gloenvcha.2013.07.006

Kim, R. E. (2020). Is global governance fragmented, polycentric, or complex? The state of the art of the network approach. *International Studies Review*, *22*(4), 903–931. https://doi.org/10.1093/isr/viz052

Kinne, B. J. (2013). Network dynamics and the evolution of international cooperation. *American Political Science Review*, *107*(4), 766–785. https://doi.org/10.1017/S0003055413000440

Lake, D. A. (2021). The organizational ecology of global governance. *European Journal of International Relations*, *27*(2), 345–368. https://doi.org/10.1177/1354066120959407
Latour, B. (2012). *We have never been modern*. Harvard University Press.
Maoz, Z. (2012). Preferential attachment, homophily, and the structure of international networks, 1816–2003. *Conflict Management and Peace Science*, *29*(3), 341–369. https://doi.org/10.1177/0738894212443344
March, J. G., & Olsen, J. P. (1998). The institutional dynamics of international political orders. *International Organization*, *52*(4), 943–969. https://doi.org/10.1162/002081898550699
Mazzucato, M., & Robinson, D. K. R. (2018). Co-creating and directing innovation ecosystems? NASA's changing approach to public-private partnerships in low-earth orbit. *Technological Forecasting and Social Change*, *136*, 166–177. https://doi.org/10.1016/j.techfore.2017.03.034
McNamara, K. (2023). Transforming Europe? The EU's industrial policy and geopolitical turn. *Journal of European Public Policy*, 1–26.
McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology*, *27*(1), 415–444. https://doi.org/10.1146/annurev.soc.27.1.415
Migaud, M. R., Greer, R. A., & Bullock, J. B. (2021). Developing an adaptive space governance framework. *Space Policy*, *55*, 101400. https://doi.org/10.1016/j.spacepol.2020.101400
Mitchell, M. (2009). *Complexity: A guided tour*. Oxford University Press.
Morin, J.-F. (2020). Concentration despite competition: The organizational ecology of technical assistance providers. *The Review of International Organizations*, *15*(1), 75–107. https://doi.org/10.1007/s11558-018-9322-7
Morin, J.-F., Louafi, S., Orsini, A., & Oubenal, M. (2017). Boundary organizations in regime complexes: A social network profile of IPBES. *Journal of International Relations and Development*, *20*(3), 543–577. https://doi.org/10.1057/s41268-016-0006-8
Morin, J.-F., & Orsini, A. (2014). Policy coherency and regime complexes: The case of genetic resources. *Review of International Studies*, *40*(2), 303–324. https://doi.org/10.1017/S0260210513000168
Morin, J. F., Pauwelyn, J., & Hollway, J. (2017). The trade regime as a complex adaptive system: Exploration and exploitation of environmental norms in trade agreements. *Journal of International Economic Law*, *20*(2), 365–390. https://doi.org/10.1093/jiel/jgx013
Morin, J. F., & Tepper, E. (2023). The empire strikes back: Comparing US and China's structural power in outer space. *Global Studies Quarterly*, *3*(4), ksad067. https://doi.org/10.1093/isagsq/ksad067
Morrison, T. H., Adger, W. N., Brown, K., Lemos, M. C., Huitema, D., Phelps, J., Evans, L., Cohen, P., Song, A. M., Turner, R., Quinn, T., & Hughes, T. P. (2019). The black box of power in polycentric environmental governance. *Global Environmental Change*, *57*, 101934. https://doi.org/10.1016/j.gloenvcha.2019.101934
Murdie, A. (2014). The ties that bind: A network analysis of human rights international nongovernmental organizations. *British Journal of Political Science*, *44*(1), 1–27. https://doi.org/10.1017/S0007123412000683
Murdie, A., & Davis, D. R. (2012). Looking in the mirror: Comparing INGO networks across issue areas. *The Review of International Organizations*, *7*(2), 177–202. https://doi.org/10.1007/s11558-011-9134-5
NASA – Glenn Research Center. (2021). *European service module*. https://www1.grc.nasa.gov/space/esm/.

Oatley, T., Winecoff, W. K., Pennock, A., & Danzman, S. B. (2013). The political economy of global finance: A network model. *Perspectives on Politics*, *11*(1), 133–153. https://doi.org/10.1017/S1537592712003593

Orsini, A., Le Prestre, P., Haas, P., Brosig, M., Pattberg, P., Widerberg, O., Gomez-Mera, L., Morin, J.-F., Harrison, N. E., Geyer, R., & Chandler, D. (2020). Forum: Complex systems and international governance. *International Studies Review*, *22*(4), 1008–1038. https://doi.org/10.1093/isr/viz005

Orsini, A., Morin, J.-F., & Young, O. (2013). Regime complexes: A buzz, a boom, or a boost for global governance?. *Global Governance: A Review of Multilateralism and International Organizations*, *19*(1), 27–39. https://doi.org/10.1163/19426720-01901003

Pattberg, P., & Widerberg, O. (2020). Global sustainability governance: Fragmented, orchestrated or polycentric? *Civitas Europa*, *N° 45*(2), 373–392. https://doi.org/10.3917/civit.045.0373

Pauwelyn, J. (2014). At the edge of chaos? Foreign investment law as a complex adaptive system, how it emerged and how it can be reformed. *ICSID Review*, *29*(2), 372–418. https://doi.org/10.1093/icsidreview/siu001

Pomeroy, C. (2019). The quantitative analysis of space policy: A review of current methods and future directions. *Space Policy*, *48*, 14–29. https://doi.org/10.1016/j.spacepol.2018.08.001

Quintana, E. (2017). The new space age: Questions for defence and security. *The RUSI Journal*, *162*(3), 88–109. https://doi.org/10.1080/03071847.2017.1352377

Raustiala, K. (2012). Institutional proliferation and the international legal order. In J. L. Dunoff, & M. A. Pollack (Eds.), *Interdisciplinary perspectives on international law and international relations: The state of the art* (pp. 293–320). Cambridge University Press.

Raustiala, K., & Victor, D. G. (2004). The regime complex for plant genetic resources. *International Organization*, *58*(2), 277–309. https://doi.org/10.1017/S0020818304582036

Roberts, A., & St John, T. (2022). The originality of outsiders: Innovation in the investment treaty system. *European Journal of International Law*, *33*(4), 1153–1181. https://doi.org/10.1093/ejil/chac065

Sagath, D., Vasko, C., Van Burg, E., & Giannopapa, C. (2019). Development of national space governance and policy trends in member states of the European Space Agency. *Acta Astronautica*, *165*, 43–53. https://doi.org/10.1016/j.actaastro.2019.07.023

Sapat, A., Esnard, A.-M., & Kolpakov, A. (2019). Understanding collaboration in disaster assistance networks: Organizational homophily or resource dependency? *The American Review of Public Administration*, *49*(8), 957–972. https://doi.org/10.1177/0275074019861347

Schelling, T. C. (1971). Dynamic models of segregation. *The Journal of Mathematical Sociology*, *1*(2), 143–186. https://doi.org/10.1080/0022250X.1971.9989794

Schemeil, Y. (2013). Bringing international organization in: Global institutions as adaptive hybrids. *Organization Studies*, *34*(2), 219–252. https://doi.org/10.1177/0170840612473551

Seabrooke, L., & Tsingou, E. (2014). Distinctions, affiliations, and professional knowledge in financial reform expert groups. *Journal of European Public Policy*, *21*(3), 389–407. https://doi.org/10.1080/13501763.2014.882967

USAspending.gov. (2022). National Aeronautics and Space Administration (NASA) | Spending Profile | USAspending. https://usaspending.gov/agency/national-aeronautics-and-space-administration.

Wang, R., Tanjasiri, S. P., Palmer, P., & Valente, T. V. (2016). Network structure, multiplexity, and evolution as influences on community-based participatory interventions. *Journal of Community Psychology*, *44*(6), 781–798.

Wang, R., & Shin, J. (2023). Determinants of alliance formation and dissolution among international health organizations: The influence of homophily and institutional power in affinity communication networks. *Management Communication Quarterly*, *37*(4), 913–940. https://doi.org/10.1177/08933189231156126

Weiss, T. G., & Wilkinson, R. (2014). Rethinking global governance? Complexity, authority, power, change. *International Studies Quarterly*, *58*(1), 207–215. https://doi.org/10.1111/isqu.12082

Williamson, O. E. (1991). Comparative economic organization: The analysis of discrete structural alternatives. *Administrative Science Quarterly*, *36*(2), 269–296. https://doi.org/10.2307/2393356

Winston, C. (2023). International norms as emergent properties of complex adaptive systems. *International Studies Quarterly*, *67*(3), sqad063. https://doi.org/10.1093/isq/sqad063

Westerwinter, O. (2021). Transnational public-private governance initiatives in world politics: Introducing a new dataset. *The Review of International Organizations*, *16*(1), 137–174.

Yavaş, M., & Yücel, G. (2014). Impact of homophily on diffusion dynamics over social networks. *Social Science Computer Review*, *32*(3), 354–372. https://doi.org/10.1177/0894439313512464

Zeitlin, J., & Overdevest, C. (2021). Experimentalist interactions: Joining up the transnational timber legality regime. *Regulation & Governance*, *15*(3), 686–708. https://doi.org/10.1111/rego.12350