Massive Institutional Structures in Global Governance

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Abstract

Global governance is a complex web of institutions. It consists of elementary regimes that form regime complexes, which in turn give rise to what we call superclusters around broad policy domains such as trade and environment. In recent years, scholars have explored what these macroscopic structures look like and how they evolve over time. Yet the complex ways in which entire governance superclusters interact and coevolve with one another through multiple inter-linkages, and what might emerge through this process, have not received much attention. In this paper, we expand the ontological frontier of global governance research by offering a first bird's-eye view on supercluster-level institutional interaction with an empirical focus on trade and environment. We constructed and analyzed a dynamic network-of-networks model consisting of 694 trade and 2,731 environmental agreements joined by 2,305 treaty citations. Our analysis reveals what we call a supercluster complex, which is a massive institutional structure in global governance consisting of two or more interlocking superclusters that exert a measurable influence on each other's course of development. Based on our exploratory analysis, we argue that the supercluster complex serves as an institutional fabric that enables the degree of self-organized coordination observed between the trade and environment policy domains. Our preliminary findings warrant more research on supercluster complexes as an important but little-noticed phenomenon in global governance.

Keywords

Introduction

International institutions have proliferated in global governance. Institutional structures of varying size have emerged as a result, ranging from elementary regimes, mesoscopic regime complexes, to what we call *superclusters* around broad policy domains. These superclusters, similar to what others refer to as architectures of global governance (Biermann et al. 2009), are large systems of institutions active in an entire policy domain of global governance such as health, security, and investment. For example, the thousands of international environmental agreements that constitute various regimes and regime complexes are part of the same global environmental governance supercluster. Conceptualizing institutions as components of nested institutional structures contributes to the structural theory of global governance (Biermann and Kim 2020), which assumes that specific institutional configurations affect the design and performance of individual institutions as well as the norms and values of international society.

Over the past decade, global governance scholars have analyzed the whole or parts of superclusters, advancing an understanding of what they look like, why, and to what effect (e.g., Morin et al. 2017). The growing interest in regime complexity has made a significant contribution in this regard with studies on regime interactions across policy domains (Alter and Raustiala 2018). Yet, the vast majority of existing studies have examined either institutions and their interactions within the bounds of a single policy domain such as the environment (e.g., Kim 2013), or a relatively few prominent cases of cross-domain interaction such as those between international organizations that belong to different policy domains (e.g., Beckfield 2010). No study has yet explored, in a single analysis, the full suite of institutional interactions between two or more governance superclusters considered in their entirety. Global governance research remains fragmented: insights on individual regimes (e.g., Young et al. 1999), their interactions (e.g., Oberthür and Gehring 2006a), and complexes that interacting regimes constitute (e.g., Biermann and Kim 2020) have not been effectively synthesized. We therefore lack a holistic understanding of the large-scale structure of global governance despite the sizeable literature on its various building blocks and structural features (Kim 2020). The time is ripe to reassemble the parts for the whole by bringing together separate strands of research.

In this study, we aim to expand the ontological horizon of global governance by illustrating how superclusters, as open systems with porous boundaries, interact with one another and shape each other's evolution. To that end, we make an analytical leap similar to those scholars made in the 2000s and 2010s for the analysis of regime complexes (Raustiala and Victor 2004) and governance architectures (Biermann et al. 2009). We zoom out until we have two complete governance superclusters under the scope, and map the uncharted space in between and identify the contours of what we call a *supercluster complex*. Here we present the first mapping and exploratory analysis of a supercluster complex in global governance. Building on the empirical

illustration of the trade and environment domains, our objective is to demonstrate the relevance of superclusters and their complexes for understanding the structure and dynamics of global governance.

In order to enable the analysis of a supercluster complex, we move beyond the conventional analysis of a single network of institutions to a "network of networks" (D'Agostino and Scala 2014). This new analytical approach is a recent innovation in network science, and it is useful for shining a spotlight on the currently opaque space between governance superclusters, and hence understanding cross-network effects and emergent properties. Although these governance systems consist of multifarious building blocks of formal and informal institutions with varying degrees of agency (Biermann and Kim 2020), we build a relatively simple model for illustrative purposes, one that consists of 694 trade and 2,731 environmental agreements joined by 2,305 citations found in their treaty texts. It is a dynamic model, constructed with longitudinal data collected for the period between 1963 and 2016.

The paper is structured as follows. We first review the literature on institutional structures in global governance, and put forward a proposition that superclusters form even larger complexes within which they are coupled in coevolutionary dynamics. We then introduce our analytical approach, and justify the use of treaty citations as a proxy for relationships between individual international institutions. Next, we turn to our empirical illustration of trade and environment and report on key findings. We pay attention to the growth and evolution of the interface between the trade and environment superclusters, the dynamics of an emergent supercluster complex, and implications for global governance. Based on our preliminary findings, we propose a new research agenda on massive institutional structures in global governance.

From superclusters to supercluster complexes

Global governance scholars have long been interested in structures formed by institutions interacting with one another, and how these structures in turn interact at a higher level of organization (Figure 1). That is because these structures serve as a constraint on (groups of) institutions operating therein, and therefore help explain their performance. Examples include *regimes* as sets of norms and rules often articulated in treaties (Krasner 1982; Young 1999), *regime complexes* as loosely coupled systems of interacting regimes (Raustiala and Victor 2004; Alter and Meunier 2009; Keohane and Victor 2011; Orsini et al. 2013), and *superclusters* as governance architectures consisting of one or more institutionally bound regime complexes (Biermann et al. 2009; Biermann and Kim 2020). For example, there is an international regime on persistent organic pollutants, which forms part of the global regime complex on the management of hazardous wastes together with the regimes on mercury, pesticides, and other harmful chemicals, and this regime complex is in turn part of the global environmental governance supercluster, made of more than 2,000 environmental agreements.
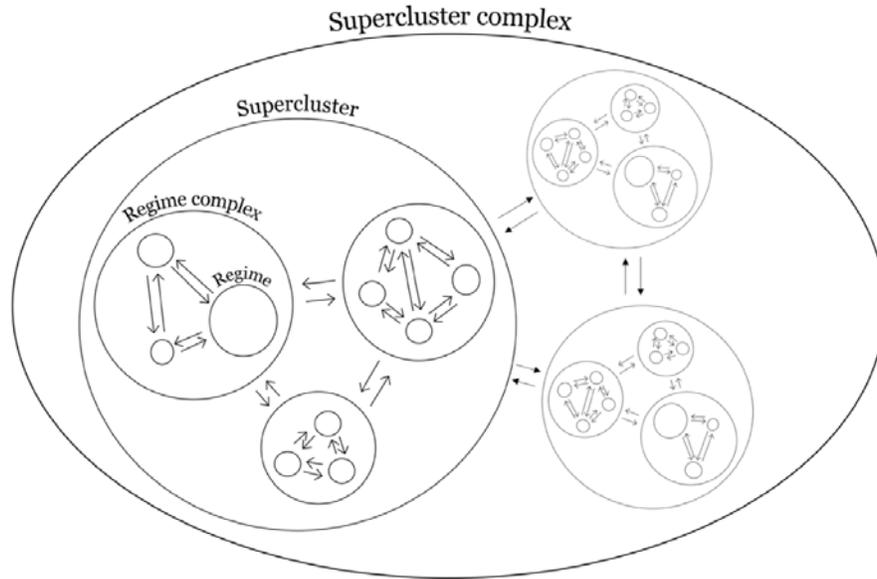
Figure 1. A supercluster complex consists of macroscopic superclusters, which in turn comprise mesoscopic regime complexes and microscopic regimes.

Although the literature is rich in studies on the interaction among elementary regimes as well as regime complexes, we observe that the complex interaction at the level of governance super-clusters have not yet been given sufficient attention. So far scholars have often approached these large institutional structures as *de facto* independent in their empirical analysis. In fact, a key purpose of studying such structures has been to compare and explain the variations found among them in terms of, for example, the degree of fragmentation (Zelli and van Asselt 2013) or differentiation (Henning and Pratt 2020), which necessarily assumes independence between superclusters as units of analysis. Such a reductionist approach has been a logical first step; we learned about the structure and evolution of individual superclusters through large-n empirical analyses of international trade (Morin et al. 2017), investment (Pauwelyn 2014), taxation (Arel-Bundock 2017), and environmental agreements (Kim and Mackey 2014). We now understand that superclusters resemble the shape of complex networks with small-world and scale-free topology, and behave like complex adaptive systems where individual elements interact locally according to some relatively simple rules and give rise to spontaneous order. These studies have also identified key endogenous processes as main drivers of change, such as institutional innovation (Colgan et al. 2012; Hollway et al. 2020), institutional layering (Faude 2020), norm exploration and exploitation (Morin et al. 2017), stress management (Young 2010), preferential attachment (Kim 2013), and niche occupation (Abbott et al. 2016).

However, recent empirical observations challenge the conventional treatment of governance superclusters as siloed systems with negligible exogenous influences on their internal dynamics (Morin et al. 2018). Mounting evidence suggests that, not just a few, but many institutions have formed a myriad of seemingly weak but important links with those outside their own

policy domain. In other words, the boundaries of governance superclusters maybe far more porous than previously assumed. The distinct populations of institutions are not merely in conflict at a small number of critical junctures, but are rather deeply interwoven to the extent that they may shape each other's evolution (He 2019; Yu and Xue 2019; Morin 2020). If so, questions about a certain supercluster cannot be fully addressed by examining it in isolation, but only in relation to other superclusters that it interacts with in a larger institutional environment.

These observations translate to a need for an ontological reflection by overcoming the inherent methodological limitations of single-case or comparative studies. The required research effort could be comparable to the previous conceptual and methodological innovations that scholars made when shifting their analytical focus from institutions to regimes in the 1980s, from regimes to regime complexes in the 2000s, and from regime complexes to governance architectures (superclusters) in the 2010s. We expect that there are even more encompassing structures with identifiable boundaries within which superclusters are nested, which we call *supercluster complexes* (Figure 1). They are massive institutional structures consisting of two or more interlocking governance superclusters that exert a measurable influence on each other's course of development. These complexes are the largest known institutional structures before considering global governance as a whole with all its policy domains.

Existing research on institutional interaction between superclusters is limited in scope for the purpose of understanding emergent properties of a supercluster complex. For the most part, the analytical focus has so far been microscopic in scale on dyadic interactions between two prominent elementary regimes, such as the World Trade Organization (WTO) and the United Nations Framework Convention on Climate Change (e.g., Oberthür and Gehring 2006a; Oberthür and Stokke 2011). When scholars did examine cross-network effects between policy domains, they failed to incorporate the insights on dyadic interactions and hence the complex patterns of institutional interdependence (e.g., Milewicz et al. 2016). This has been apparent in studies that adopted the organizational ecology framework to examine how populations of international institutions compete and coevolve, but at the cost of losing the nuanced picture of who interacts with whom and in what ways (e.g., Abbott et al. 2016). Despite the call for a systematic exploration of "complex interaction settings and their emergent properties" (Gehring and Oberthür 2009, 148), we still lack an analysis that considers all cases of institutional interaction found across and within global governance superclusters.

The limitations of the current analytical approach are pronounced in the literature on trade and environment. The two policy domains have been treated as distinct governance superclusters that evolve primarily through internal logic (e.g., Kim 2013; Morin et al. 2017). To the extent their nexus is examined, most scholarly attention has been placed on a small number of prominent junctures at which the WTO as a "large tiger" and multilateral environmental agreements as "a ragged collection of small cats" meet (Eckersley 2004, 24). For example, Oberthür

and Gehring (2006b) show how the WTO constrained the use of trade measures related to genetically modified organisms under the Cartagena Protocol on Biosafety, which in turn impeded the development of further rules on genetically modified organisms within the WTO. The more recent literature on regime complexes has highlighted how multiple regimes that belong to different policy domains interact with one another. However, as regime complexes form around specific issues such as energy (Colgan et al. 2012) or genetic resources (Raustiala and Victor 2004) that cut across policy domains, the mapping and analysis of regime complexes still shows only a part of the bigger picture. In sum, existing studies on regime interactions and regime complexes say little about how two governance superclusters interact in their entirety and possibly constitute a discernible complex of superclusters.

The conventional analytical approach has not fundamentally changed despite the recent growth of the trade and environment nexus driven by the proliferation of preferential trade agreements with extended environmental chapters (Jinnah and Morgera 2013). Some population-level studies have been conducted to explain the factors that led to the inclusion of environmental provisions in trade agreements (e.g., Lechner 2016; Milewicz et al. 2016; Morin et al. 2019; Hollway et al. 2020) and their actual impact on the environment (e.g., Bastiaens and Postnikov 2017; Peinhardt et al. 2019). But these analyses suffer from the inherent limitations of dyadic design where institutional interactions are assumed to be independent from one another (Cranmer and Desmarais 2016). If we accept that these cases of interaction are not completely isolated from one another but embedded in complex interdependent relationships, one would need to build and analyze a connectivity map with information on which of their individual institutions are coupled. We may then find out to what extent governance superclusters have converged over time, how they influence each other's evolution, and if a qualitatively different, more encompassing structure has emerged.

The trade and environment nexus provides a good testing ground for our proposition, that global governance superclusters are less siloed than the literature on governance superclusters appears to accept and, therefore, coevolving. We expect the nexus boundaries to have become blurred in recent years to the extent that endogenous processes taking place in the trade supercluster have a significant impact on what is happening in the environment supercluster, and vice versa. Such exogenous, cross-domain processes are expected to have a nontrivial degree of influence on the structure and evolution of both superclusters, as well as their collective dynamics such as coordination and synchronization between the two (e.g., Boccaletti et al. 2006; Arenas et al. 2008).

A network-of-networks approach using citations

To enable an analysis of a supercluster complex in global governance (consisting of two or more superclusters), we borrowed a framework called "network of networks" from network science.

It is a relatively recent innovation by network scientists studying complex networks consisting of two or more interdependent networks (Buldyrev et al. 2010; Gao et al. 2011; Gao et al. 2014). The framework is useful to map how multiple networks are interconnected, analyze their interactions, and identify and explain the nature of their relationships.

As illustrated in Figure 2, networks A and B evolve through their own endogenous processes but they are not completely independent from one another; rather the networks are open systems that exchange resources and information. The evolution of one network is therefore affected by another, and the two networks coevolve as a network of networks. Through interaction, collective dynamics such as certain forms of co-existence or coordination emerge. What is peculiar here is that the two networks may come into sync even if the dynamics within each network is not perfectly in sync (Kenett et al. 2015). Such characteristics make a network of networks different from a single network with a modular structure.
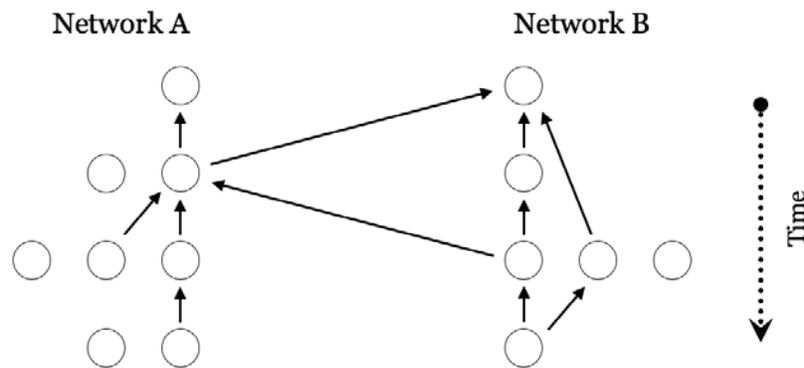

Figure 2. An illustrative example of a dynamic network of networks, consisting of two different sets of nodes (or institutions in our case) joined by directed links (citations).

Using this framework, we mapped the trade and environment governance superclusters and conducted a network analysis (Hafner-Burton et al. 2009). Our network-of-networks model includes 694 trade and 2,731 environmental agreements, which were adopted since 1947 and 1867, respectively, as well as 2,305 treaty citations found therein, including 495 cross-domain citations created since 1963. We compiled a list of these agreements with information from the Design of Trade Agreement Project (Dür et al. 2014) and the International Environmental Agreement Database (Mitchell et al. 2020), which include both bilateral and multilateral agreements. For citation data, we relied on multiple sources including a dataset of environmental provisions in trade agreements (Morin et al. 2018), an updated version of a dataset on citations between environmental agreements (Kim 2013), and our own datasets of citations among trade agreements as well as trade provisions in environmental agreements, collected for the purpose of this analysis.

Citations between international agreements have become a widely-observed phenomenon in global governance (Kim 2013; Ahlström and Cornell 2018; Perez and Stegmann 2018). For

example, a trade agreement often contains one or more references to another trade or environmental agreement to recognize its relevance or to define the relationship between the two. A well-known example can be found in the North American Free Trade Agreement (NAFTA) which provides legal precedence to specific multilateral environmental agreements in case there is an inconsistency with NAFTA. These citations are a specific class of environment-related provisions in trade agreements (Monteiro 2016) or trade-related provisions in environmental agreements (UNEP 2007), which may or may not point to certain agreements.

We conceptualize citations as a type of direct institutional link between international agreements (Sommerer and Tallberg 2018). As institutional links, treaty citations perform a number of functions. In general, they extend the effect of one agreement to another. For example, Kiss and Shelton (2007, 87) observe that citations among environmental agreements, in particular, "extend the legal effect of these instruments to states that have not ratified them but which ratify the texts that cite them". This is, for example, one way through which the influence of the United Nations Convention on the Law of the Sea extends to its non-parties such as the United States, through NAFTA that makes reference to the law of the sea convention.

Furthermore, citations may appear when parties wish to coordinate two regimes and address negative spillovers from one regime to another (Johnson and Urpelainen 2012). Consider the situation where cooperation through a trade agreement undermines the pursuit of the objective of an environmental agreement. The parties to the trade agreement may wish to make reference to the environmental agreement to coordinate their activities. Vice versa is also true: an environmental agreement might hinder trade, therefore it may cite affected trade agreements to mitigate its impact. A treaty citation is therefore an indication that the parties to an agreement agree not to prioritize their preferred issue at the expense of an issue covered by another agreement.

Seen in this light, citations have different effects on agreements that make them and agreements that receive them. On the one hand, citations enhance the normative legitimacy of citation-making agreements. By acknowledging and mitigating their negative spillovers to another affected institution, these citations help legitimize the institutions that create a negative impact (Faude and Große-Kreul 2020). On the other hand, citations promote the regulatory authority of the agreement being referred to as an institution that is important to be protected from negative spillovers. This is particularly apparent in trade-to-environment citations. As Jinnah (2011, 192) argues based on her study of the United States-Peru Trade Promotion Agreement and the Convention on International Trade in Endangered Species (CITES), the trade agreement not only mandates the implementation of CITES but also "effectively transfers its much stronger regulatory authority to CITES, which ultimately has the potential to increase CITES effectiveness in ways that have been impossible under CITES alone". All in all, citations matter not only on paper but also in practice.

The case of trade and environment

We now report on key findings of the exploratory analysis of our network-of-networks model, which consists of trade and environmental agreements joined by treaty citations.

The growth and evolution of the interface

Over the years, trade and environmental agreements have self-organized into two distinct governance superclusters. Some of these agreements made not only internal but also external connections, giving rise to an institutional interface between the two superclusters. Figure 3 shows the growth in both the number of agreements at the interface as well as the number of cross-domain citations that some of these agreements have created. It is visibly clear that the rate at which the interface grew increased around 1990 and 2005, primarily due to changes in the trade governance supercluster. In particular, the average number of cross-domain citations that an agreement makes has clearly exceeded 1 since 2005. This signifies the beginning of cross-domain structural integration or convergence.
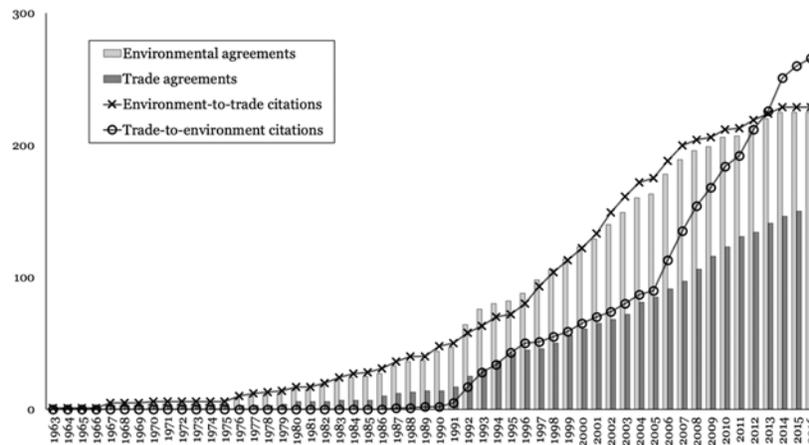

Figure 3. Cumulative number of agreements and cross-domain citations at the interface.

A bird's-eye view on the growth and evolution of the interface corresponds with what happened in the real world. In the beginning, the two superclusters emerged independently from each other. There was some degree of engagement from environment to trade, starting with the very first cross-domain citation found in the 1963 treaty between the Netherlands and Belgium concerning the Scheldt and Rhine rivers, which refers to the Benelux Economic Union Treaty. Subsequently, more environmental agreements (mostly fisheries) began citing trade agreements such as the General Agreement on Tariffs and Trade as well as other regional ones including the European Economic Community and the Caribbean Community. In contrast, trade agreements rarely made reference to an environmental agreement until 1990.

From the early 1990s, bidirectional interaction started between the two policy domains. This timing coincides with the broad diffusion of the concept of sustainable development and

the institutionalization of the "compromise of liberal environmentalism" (Bernstein 2001). Tellingly, the 1992 Rio Declaration on Environment and Development stressed the importance of an "open international economic system" and warned against "restriction on international trade" (Principle 12). Two years later, the 1994 Marrakesh Agreement establishing the WTO was adopted with reference to the "objective of sustainable development, seeking both to protect and preserve the environment" (preamble). Against this backdrop, mutual interaction between trade and environment emerged. On the one hand, bilateral environmental agreements engaged with key global and regional trade agreements and bound themselves to be consistent with the trade rules. On the other hand, some of the new trade agreements began adopting environmental provisions, including references to specific environmental agreements. These references emerged in, for example, the bilateral trade agreements formed by the European Community with its key trading partners such as Hungary, Poland, Bulgaria, and Romania, and major multilateral environmental agreements such as CITES and the Basel on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal.

The tide turned in 2006 with a new wave of "deep" preferential trade agreements that has driven the inter-system dynamics up until today (Dür et al. 2014; Mattoo et al. 2020). These preferential trade agreements have provided an increasingly deep degree of integration and covered in ever more detail environmental protection (Morin et al. 2018). Environmental provisions have become common in trade agreements, many of which contain more than one reference to multilateral environmental agreements. These recent trade agreements have also been more assertive than before, requiring their parties to implement obligations under the specific environmental agreements they cite (Laurens and Morin 2019). Notably, many of these preferential trade agreements have also given legal precedence to a number of multilateral environmental agreements such as CITES. By incorporating environmental provisions, the trade agreements have in effect gained in normative legitimacy and strengthened environmental governance (Morin and Jinnah 2018).

Figure 4 presents visualizations of how the two superclusters (modelled as systems of treaties) have emerged and evolved over the timespan of 50 years. The large institutional network of networks that we find as of 2016 consists of 3,425 agreements and 2,305 citations. Among which 377 agreements (152 trade and 225 environmental) and 495 citations (229 environment-to-trade and 266 trade-to-environment citations), or an impressive 20 percent of all citations, are found at the cross-domain interface. There is a clearly visible giant component with 1,095 agreements joined by 2,125 citations, which represent 32 percent and 92 percent of all agreements and citations, respectively. As expected, a relatively small number of agreements have attracted most of the citations. Only 43 environmental agreements are cited by 117 trade agreements, and 52 trade agreements are cited by 190 environmental agreements.
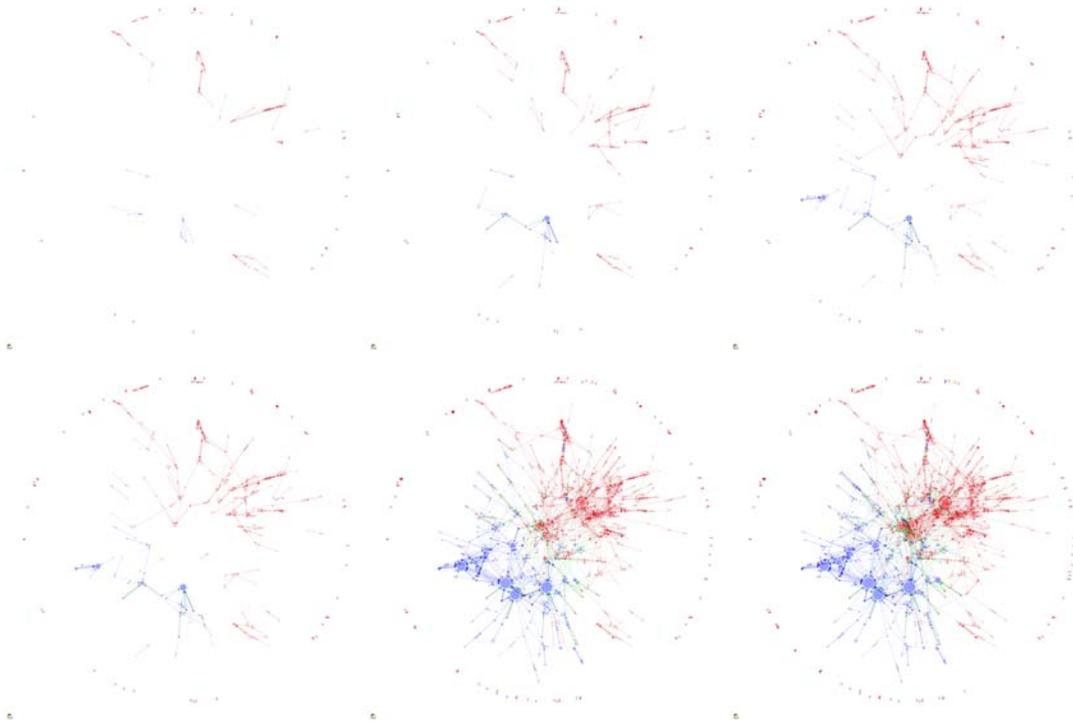
Figure 4. The supercluster complex of trade and environment in 1966, 1976, 1986, 1996, 2006, and 2016. Trade agreements are in blue, environmental agreements are in red, and cross-domain citations are in green. Node size corresponds to the number of citations each agreement makes and receives. Isolates are not shown. Visualized using a force-directed algorithm.

We ran a cluster adequacy test to assess the degree of integration or separation of the two superclusters. The test used two metrics. We calculated a specific type of network modularity called Louvain modularity (Blondel et al. 2008), which measures the strength of division of a network into, in our case, the two superclusters. The modularity measure was complemented by the E-I index, which is a ratio of external to internal links (Krackhardt and Stern 1988).
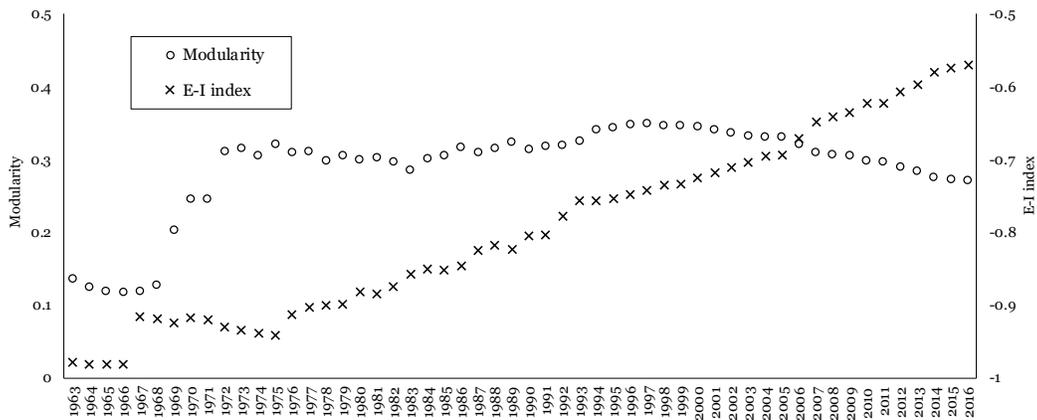

Figure 5. Changes in Louvain modularity and E-I index values in the combined network. The modularity value of 1 means the trade and environmental governance superclusters are disconnected while the E-I index value of 1 indicates that all connections are found between them.

Overall, the strength of the division has diminished over time (Figure 5). Trade and environmental agreements emerged in distinct clusters, and the overall structure maintained a high level of modularity until the end of the 1990s. Only a couple of years following the establishment of the WTO, a new structural shift emerged as indicated by the peak modularity in 1997. This indicates that the boundary between the two superclusters started to become fuzzy and the two policy domains have since increasingly become intertwined, and therefore, structurally less fragmented. During this period, more than half of all new references found in both trade and environmental agreements were made between the two governance superclusters, with the proportion rising to almost 70 percent in the most recent reading in 2016. This is also apparent through the steady increase in the E-I index score after reaching a low in 1975. The measures indicate that inter-domain integration occurred at a faster rate than intra-domain integration.

In sum, the two governance superclusters for trade and environment have gradually become entangled over time. The growth of the trade-environment nexus has been driven by myriad independent decisions made when negotiating individual agreements to coordinate with key institutions operating in the opposite policy domain. Today, the connectivity between the two superclusters seems to have reached a sufficient level to justify that, from a structural perspective, a larger, more encompassing interlocking structure has emerged within which both trade and environmental agreements are embedded. We call this a supercluster complex.

The dynamics of the supercluster complex

We report that the trade and environment governance superclusters are coupled in causal chains that cut across scales. Generally speaking, in a causal chain, the impact of an interaction case between two institutions affects another case that influences a third institution, which in turn has an impact on others until a loop is closed (Gehring and Oberthür 2009). In the context of trade and environment, this chain of interaction links major and minor agreements of global or regional and bilateral in scope, respectively.
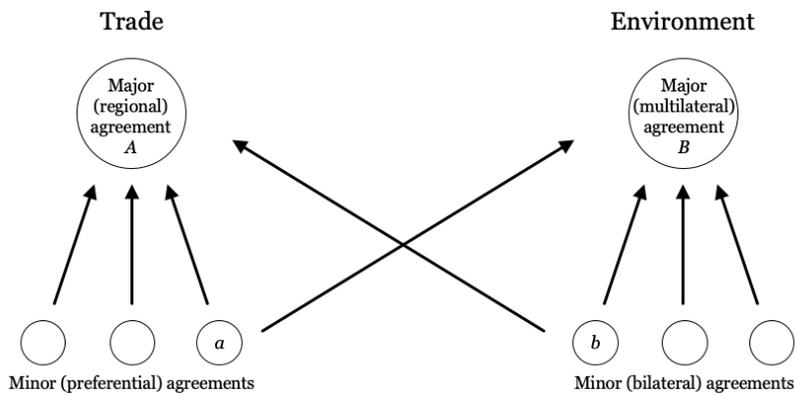

Figure 6. The trade and environment superclusters are coupled across scales. The pattern of interaction illustrates how legal effects and regulatory authority flows between superclusters.

Figure 6 presents a schematic illustration of the causal chains. Here, a relatively minor agreement *a* refers to a major agreement *B* in another domain. In the process, agreement *a* transfers part of its regulatory authority to agreement *B*, but gains in normative legitimacy. The authority transferred to agreement *B* in turn strengthens other smaller agreements *b* in the same policy domain through internal mechanisms. Some of these empowered agreements in turn make connections to a major agreement *A* in the other domain. Often this agreement *A* is not directly linked to the minor agreement *a* that caused the cross-domain interaction in the beginning, but remains under its influence, thereby closing a causal loop.

This pattern of interaction is prevalent around most major agreements found in the super-cluster complex. For example, 61 preferential trade agreements contain provisions that promote, implement, or give precedence to CITES. Among them is the United States-Colombia Trade Promotion Agreement, which requires both parties to "adopt, maintain, and implement laws, regulations, and all other measures" to fulfil their obligations under CITES and other listed multilateral environmental agreements. As a result, CITES gains in regulatory authority transferred from the trade agreement, which then flows on to many other environmental agreements. The cascading effect is traceable in particular to 24 biodiversity-related agreements that reference CITES as authority (and these agreements form a meso-level structure, or a regime complex shown in Figure 1). This includes, for example, the Inter-American Convention for the Protection and Conservation of Sea Turtles that obligates its parties to "take appropriate and necessary measures" to comply with CITES. Seven among these CITES-citing environmental agreements, including the sea turtles agreement, then link back to the trade governance super-cluster, by citing one or more among six major trade agreements including the General Agreement on Tariffs and Trade and the Marrakesh Agreement Establishing the WTO.

The same interaction pattern is also observed in the opposite direction. For example, the bilateral environmental agreement between Germany and Russia of 1992, along with 24 other similar agreements, contains a reference to the Treaty Establishing the European Economic Community (EEC Treaty). This reference obliges the parties to take into account the "existing norms and standards of the European Economic Community", thereby strengthening the EEC Treaty. The impact of this reference then spills over to other relevant trade agreements, especially to those 121 trade agreements that refer to the EEC Treaty as authority. Among these are 31 trade agreements that feed back through to the environment domain by making references to a total of 21 multilateral environmental agreements, including CITES mentioned above.[1]

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[1] Others include the United Nations Framework Convention on Climate Change and its Kyoto Protocol, the Convention on Biological Diversity, the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, the Basel on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, the Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat, and the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978.

The cross-domain and cross-scale pathways of institutional interaction as illustrated in these examples create an interlocking web of compatibility requirements that connects the two competing policy domains. Although major agreements are not directly linked to one another, they are not completely free from each other's influence because of the minor agreements that join them together. Furthermore, regulatory authority transferred from minor agreements to major agreements flow on and cascade across a governance supercluster. Importantly, this systemic impact is not confined to the bounds of the domain where referenced agreements are found. The influence flows back and forth through the myriad cross-domain links that constitute a porous interface. In this way, governance superclusters reinforce each other, and inter-domain interaction (exogenous processes) has a meaningful impact on intra-domain dynamics (endogenous processes), and vice versa.

While the patterns of cross-domain interaction are symmetrical, the dynamics is not. Trade agreements exert a greater impact on the environment supercluster than environmental agreements do on the trade supercluster. This is in part due to a significant proportion of trade-to-environment citations demanding their parties not only to acknowledge or cooperate, but to implement or ratify an environmental agreement. Over 88 percent of them provide that an environmental agreement should prevail in the case of inconsistency. Furthermore, a significant number of trade agreements also create generic references to all "relevant", unspecified multilateral environmental agreements, thereby making a significant impact on the environment supercluster that is not captured in our network model. For example, 22 trade agreements provide legal precedence to all existing environmental agreements to which their parties are party; 151 trade agreements require their parties to implement relevant multilateral environmental agreements; and 88 trade agreements make other types of references.

Implications for global governance

The emergence of a supercluster complex and the collective dynamics between two competing policy domains have significant implications for global governance. In this section, we make some inferences from the observed structure and dynamics of the network of networks.

We conjecture that the trade-environment supercluster complex serves as an enabling condition for mutually supportive relationships to emerge and spread between the two policy domains. The interlocking structure is a consequence of the myriad, uncoordinated, microscopic attempts to coordinate institutions and address negative spillovers from one policy domain to another. The emergent supercluster complex, in turn, creates an institutional fabric that serves as an enabling condition for the individual institutions to operate with minimal friction. Many institutions are required to be implemented or interpreted in light of those they interact with, especially those that they cite in the opposite policy domain. Not a single trade agreement is explicitly hostile toward an environmental agreement by prohibiting its ratification or claiming

its hierarchical superiority. As such, the supercluster complex counteracts the general tendency for mutually disruptive interaction (Gehring 2011) and facilitates a mutually supportive relationship (Sanwal 2004; Pavoni 2010).

This is to some extent observed in practice. Perhaps the most striking evidence is the small number of disputes related to environmental agreements that arose to date through preferential trade agreements. In light of the significantly weakened WTO and the fact that some environmental agreements include trade-restrictive provisions, many commentators expected that the trade-environment relationship to become more unpredictable and result in numerous challenges for environmental agreements under preferential trade agreements (Jo and Namgung 2012). But this has not been the case. We have instead witnessed cross-domain convergence between trade and environment.

The topology of the emergent supercluster complex is a key variable that affects the observed degree of compatibility. Our network analysis shows that average path length in both trade and environment superclusters have declined after peaking in the late 1980s and the early 1990s, respectively, while maintaining a high degree of local clustering. This indicates that both superclusters are "small worlds", or a structure where most institutions are only a small number of steps apart from one another (Kim 2020). Bridged by cross-domain links, the emergent supercluster complex can also be characterized as a small world. As an efficient structure for self-organized coordination and synchronization in the absence of hierarchical control (Watts and Strogatz 1998), we expect this small-world topology to have a significant role in shaping the collective dynamics of the complex of superclusters.

The mapping and analysis of a supercluster complex in the trade and environment context implies that global governance may not be as fragmented as some might argue, both structurally and functionally. Governance superclusters continue to remain distinct with a certain division of labor (Gehring and Faude 2014), but as our analysis suggests, at least some of these superclusters seem to be gradually converging into an interlocking megastructure and become institutionally bound to each other. The increasing multiplicity of institutions in recent years did not lead to fragmentation between the trade and environmental governance superclusters, but rather brought them closer together. This is because the new institutions came with cross-domain links that joined the two, as evidenced by decreasing modularity (e.g., Kim 2013; Gomez and Parigi 2015; Greenhill and Lupu 2017; Perez and Stegmann 2018). Institutional proliferation, somewhat ironically, has given rise to order (see also Green 2013; Faude and Groβe-Kreul 2020). We therefore conjecture that global governance as a whole may be increasingly becoming structurally more polycentric and functionally more flexible across policy domains than the conventional wisdom seems to suggest (Keohane and Victor 2011; Zürn and Faude 2013).

Another consequence of supercluster complexes is that abrupt and discontinuous changes might be increasingly difficult to operate. These complexes allow for incremental adaptation

and increase the overall resilience of global governance. Although populist leaders might criticize specific international institutions and put them in danger, they are unlikely to torn apart a complex web such as a supercluster complex. Likewise, an increasing number of experts claim that the liberal global order proves itself unfit to face the challenges of climate change, but an alternative order is unlikely to emerge as existing supercluster complexes are deeply rooted.

Future research directions

The present analysis was motivated by the relative lack of knowledge on the state of affairs beyond the scale of individual global governance superclusters. As we zoom out, we begin to see the contours of a supercluster complex in which institutionally bound superclusters are embedded. Our empirical focus has been the trade and environment nexus, but we expect the supercluster complex we identified to be much larger than what we unraveled here for illustrative purposes. The giant web may extend well beyond the two policy domains to others such as labor, health, and development. Therefore, we propose and outline below a new research agenda on supercluster complexes of global governance.

The first pillar of the research agenda is the emergence of supercluster complexes and their evolution. Why do supercluster complexes look as they do? Why do some complexes converge more than others? In the case of trade and environment, the convergence of the two domains occurred simultaneously with the decentralization of the previously centralized trade supercluster. The trade supercluster was indeed heavily centralized to the extent the reconciliation of trade and environment had become too difficult to operate centrally at the WTO. Based on this observation, we hypothesize that the degree of convergence partially depends on the degree to which a supercluster is centralized around a hierarchical authority. The more a governance supercluster is centralized, the more likely it will remain separate from other governance superclusters. Furthermore, one may ask whether governance superclusters are coevolving by exerting selection pressure on one another. We can infer from our findings that the internal adaptive dynamics of a supercluster may affect its external relations, and cross-domain interaction may in turn change the way in which a governance supercluster evolves over time. In other words, endogenous and exogenous factors may be closely coupled in coevolutionary dynamics, and hence driving the evolution of larger supercluster complexes in global governance.

The second research pillar is the consequences of supercluster complexes on institutional effectiveness. How do supercluster complexes affect the overall effectiveness of superclusters and other regimes embedded therein? Also, what do their structure and dynamics imply for global governance considered in its entirety? Our analysis suggests that supercluster complexes, as the largest known structures in global governance, serve as an institutional fabric that holds fragmentary regimes together. This view reinforces the idea that global governance is best characterized as a polycentric system where independent institutions mutually adjust to each other

and maintain some degree of order towards collectively contributing to achieving an overarching goal (Jordan et al. 2018). However, one could also explore if there are any side effects to the emergence of supercluster complexes. For example, we expect to see a greater risk of cascading regime failures from increased interdependence between separate policy domains. That is to say, if international cooperation fails under one major agreement in one policy domain, international cooperation under other major agreements in another policy domain may also be adversely affected. The increasing degree of interconnectivity between governance superclusters also implies that it has become more difficult for powerful actors to shape policy outcomes as they wish. In that sense, the emergence of supercluster complexes has implications for power dynamics between actors such as states (Alter and Meunier 2009). But contrary to the prevailing view that international regime complexity strengthen rather than weaken powerful actors (Drezner 2009; Hafner-Burton 2009), our findings suggest that institutional complexity improves the resilience of the global governance system (Duit et al. 2010).

The third pillar of the proposed research agenda is policy implications. The structural intricacies of the space between governance superclusters we revealed here implies that no single actor or institution will have a transformative impact on the trade-environment nexus, either a positive or a negative one. The WTO does not provide the centralized strength that some environmentalists worry about, nor can a world environment organization rebalance the trade and environment interplay as some suggest (e.g., Biermann and Bauer 2005). In fact, centralizing the global environmental governance supercluster may come at the cost of making cross-domain reconciliation more difficult to achieve. Any reform of the complex global governance system will have unintended consequences (Orsini et al. 2020). Managing the nexus and improving institutional performance would therefore require a knowledge of global governance as an intricate web of interlocking superclusters and their complexes. When global governance is understood and analyzed as such, strategic network interventions could be devised to enhance *overall* governance effectiveness by taking into account interdependencies between international institutions (Valente 2012).

Conclusion

Global governance is a giant web of institutions organized in complex, non-uniform ways. Over the past few decades, scholars have advanced our understanding of the structure and evolution of global governance, but little is known beyond the scale of individual governance superclusters. In particular, the space between superclusters has remained opaque because superclusters have not been empirically analyzed as fully open systems with countless external links. Motivated by this gap in the literature, our study sought to contribute to a broader understanding of complex ways in which governance superclusters interact. We took a network-of-networks approach to provide a bird's-eye view of the institutional environment of superclusters, while not

losing sight of which elementary institutions are interacting with which others and in what ways. In doing so, we make two main contributions to the literature. The first is theoretical: we offer a preliminary account of the emergence and development of a supercluster complex, and a new research agenda on massive institutional structures in global governance. The second is methodological: we demonstrate the usefulness of the network-of-networks approach in highlighting cross-network effects, which could be applied to the analysis of other global governance networks such as regime complexes.

Using the trade and environment nexus as an empirical illustration, we found that governance superclusters may not be as separate as one might have expected. The two superclusters have come to interact over time, the interface between them has grown increasingly dense and complex. Today, the two governance superclusters are no longer sparsely connected to each other when compared to the density of internal connections. From a structural perspective, a complex of superclusters, which we call a supercluster complex, has emerged as cross-domain connectivity grew faster than intra-domain connectivity.

As open rather than closed systems, the dynamics of individual superclusters are closely coupled with one another. Key causal chains are identified in the emergent supercluster complex. Minor agreements from one supercluster make cross-domain links to major agreements, which then cascade widely across the target supercluster, some of which transfer back to the originating domain. An institutional fabric of interlocking obligations is created, which serves as an enabling condition for enhanced collective dynamics such as coordination between the competing policy domains. We suggest the presence of a supercluster complex may explain why we observe a higher degree of compatibility and complementarity across global governance domains compared to what a fragmentation perspective would expect.

Our findings support the view that "the era of siloed global governance is over" (Morin and Jinnah 2018, 562). Global environmental governance is not an exclusive domain of environmental institutions, and nor is global trade governance a domain exclusive to trade institutions. The complex interaction between these open systems of institutions is now having a significant impact on each other's structure and dynamics. Therefore, the overall performance of global environmental governance, for example, can no longer completely be explained through internal factors or through the impact of only a handful of key external institutions such as the WTO. Any serious attempt at significantly improving this nexus to better reconcile trade and environmental policies will require a better understanding of supercluster complexes as a new level of analysis.

Here we made a first attempt at investigating the interaction between global governance superclusters. We invite others to join us in exploring this uncharted territory in global governance research.

Biographies

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