

THE FORUM

Complex Systems and International Governance

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This collection of essays brings together scholars from various disciplinary backgrounds, based on three continents, with different theoretical and methodological interests but all active on the topic of complex systems as applied to international relations. They investigate how complex systems have been and can be applied in practice and what differences it makes for the study of international affairs. Two important threads link all the contributions: (i) To which extent is this approach promising to under-

stand global governance dynamics? (ii) How can this be implemented in practice?

Keywords: Complex systems, global governance

Introduction

That we live in an age of complexity and transition is hardly news. Ours is the age of interconnections, ambiguity, and uncertainty; of the diffusion of authority; of various kinds of revolutions: military, technological, social, political, economic, and even philosophical. What springs from these developments is the feeling of a lack of control. Decision-makers either think they have no other option but to act as they do or are paralyzed by the uncertainties and conflicting pressures they face. The usual solution is to try to reassert control, which leads to new problems. Paradoxically, as our tools to make sense of and control societies and our environment increase, our ability to do so diminishes.

One major reason of this state of affairs lies in the difficulty of going beyond the analytical thinking approach that has served us so well to investigate complexity. Complexity indeed lies in opposition to classical analytical thinking. To illustrate this shift of perspective, complexity scholars distinguish between the “complex” and the merely “complicated.” (Morin 1990) Something “complicated,” such as a jet engine, can be approached by cutting it down into manageable parts. Complex problems, on the other hand, cannot be reduced or simplified without being strongly altered or “mutilated,” and their behavior is not predictable from the study of their parts (Morin 1990). Hospitals’ emergency units, terrorist organizations’ networks, or wild bee colonies are typical complex systems.

Much recent work attempts to show the limits of current thinking and the need to forego the prevailing doxa that confuses coordination with control and ignores whole developments in the study of international governance that point to different dynamics. Even though a spate of books, special issues, and articles have eloquently made the case for “embracing complexity” (Boulton, Allen, and Bowman 2015), international relations (IR) scholars have been slow to do so. The profession uses the vocabulary but either forgets the supporting reasoning or rejects it outright as a potential paradigm of IR.

In practice though, scholars have increasingly turned their attention to the problems raised by the behavior of complex systems, notably through models of cooperation, network analysis, the study of regime complexes and boundary-organizations, or multiscalar governance. In many ways, research largely follows the development of instruments of governance that de facto respond to the challenge of steering a complex system. Intellectually though, the prevailing discourse, both in academia and in politics, remains steeped in analytical linear thinking that emphasizes centralized authority and prediction. This is the case in most classical IR theories, such as realism, liberalism, neorealism, neoliberalism, or constructivism. Nowhere was this schizophrenia more evident than in the analyses and comments surrounding the twenty-first Conference of the Parties to the climate change negotiations. Prevailing representations were centered on the role of major emitters for the adoption of a strong intergovernmental agreement, while the actual dynamics within the negotiations overcame traditional state politics to include a bottom-up evolutionary approach to climate change commitments (see also the contributions below).

To be sure, the interest in conceptualizing complexity is not new. IR theorists have been looking at complexity at least since the late 1990s. Since [Jervis’ 1997](#) book and [Harrison’s](#) edited book in [2006](#), authors have amply demonstrated the potential usefulness of this approach and suggested ways in which it could alter our thinking

and advance systemic approaches (e.g., [Bousquet and Curtis 2011](#)). Nevertheless, it has yet to fulfill its promises and be widely used. [Kavalski's \(2007\)](#) characterization of the emergence of a fifth debate sounds today more like wishful thinking than a description of a movement under way. Yet, the current search for new models of international governance, away from a centralized perspective, forces us to take a harder look both at the promises and at the limitations of models based on complex systems.

One difficulty lies in separating the characteristics of a complex system (how do we recognize it?) from its properties (how does it behave and with what consequences?). Too many definitions confuse causes (the characteristics) with consequences (the properties) and prevent us from asking questions regarding which characteristics of the system lead to what kind of properties ([Le Prestre 2017](#)). Moreover, complexity “theory” is diverse, and there is no monolithic complexity science. It corresponds to a set of approaches, rather than one coherent theory, used to analyze complex systems. While variants of complexity thinking differ in terms of their ontological and epistemological orientations on how to analyze complex systems (see [Byrne and Callaghan 2014](#)), all proponents agree on a few basic characteristics and properties of such systems, the phenomenon rather than the analytical approach (derived from physics or biology, for example), serving as the federating element.

In this forum we build on former attempts of conceptualization (notably [Bousquet and Curtis 2011](#), 51) and define complex systems as open systems—that is, exchanging information with their environment—that include multiple elements (units) of various types intricately interconnected with one another and operating at various levels. This means that political issues are interconnected in a multiscale and networked world, although there is unpredictability about which issues may be coupled and to what extent. Complex systems provide a potentially innovative perspective on global governance in that they allow studying governance systems at an aggregate level, these systems being aggregations of regulations, institutions, rules, actors, norms, and decision-making procedures in various combinations.

Complex systems display unique properties. A first property is self-organization, meaning that order does not rely on a clear authority but on the system itself and on its multiple interactions. Uneven nonlinear interactions among units create multiple feedback loops that lead to a range of possible outcomes. Positive feedbacks can readily emerge from unit interactions with each other and with the system that might magnify small causes into large effects. In complex social systems, the range of possible paths toward equilibria, or equifinality, is extensive, since issues are not merely technical but also normative and political. Regime complexes can be considered examples of self-organized structures in a given issue-area (see [Alter and Meunier 2009](#), 15; [Orsini et al. 2013](#)).

A second property, emergence, is at the core of the notion of complex systems and of what makes them particularly interesting. Emergence is usually referred to as systemic unexpected outcomes, illustrated by the expression that “the whole is greater than the sum of its parts.” However, this expression is misleading for, as [Jervis \(1997\)](#) points out, the sum is not only greater but most of all different. Unexpected patterns, processes, or properties arise from interactions among the elements of the system.

Finally, a third property, adaptation, refers to the potential capacity of units to learn from and coevolve with their environment. Units coevolve and affect the system, which in turn affects their capacity for coevolution. Adaptation or the failure thereof takes place at the unit level, but evolution is a systemic property that may, for example, be characterized by the disappearance of certain units, as when successful specialization impedes adaptation to changing circumstances. In a sense, the expression “complex adaptive systems” ([Miller and Page 2007](#)) is a misnomer. Units adopt strategies of adaptation that may or may not be successful

but which, nevertheless, lead to the evolution of the system as other units react to them. Whether the result is “adaptive” depends on the distribution of preferences among units regarding desirable outcomes, such as agreement on common goals and adoption of synergistic policies.

Each of these properties and their degree of achievement induce contradictory dynamics. First, while complex systems might seem chaotic, as a result of multiplicity and feedback loops, self-organization and adaptation mean that they also know phases of continuity in the form of: equilibrium when no unit has an incentive to change the rules; stability as the maintenance of these rules over time in the face of disruption; and resilience as the capacity to return to a stable state that may or may not be different from the initial one. Just as certain ecosystems can be constant and persistent thanks to uneven disruptive events such as forest fires, complex systems constantly regenerate themselves after destabilizing situations or evolve into new ever more complex systems. Second, like other systems, complex systems might be subject to path dependency, but they also regularly present surprises and unexpected outcomes. They may also become dysfunctional if there is no coevolution or even crash after having reached a tipping point. Complexity science, therefore, lies in opposition to classical analytical thinking and simple system theory. Relationships are key to understanding (unexpected) behavior.

Beyond its heuristic value, to be useful, the approach itself has to be operationalized (Young 2017). How can complex systems thinking facilitate a policy-oriented agenda? How can we reconcile what takes place at different levels of governance, and how can we foster synergies among them? Are standard computational approaches feasible? Many approaches to contemporary international governance reflect an adaptation to complexity, such as insisting on local participation in order to address potential nonlinear effects (Clemens 2013) or promoting a dialectical construction of the science-policy interface. These developments are conceived outside a complex intellectual framework, however. Rather, they seek to respond to specific problems and are appended to linear frameworks. Yet, we have de facto entered the complexity era. The issue is how governance should be conceived with regards to complex systems. The very notion of governance, as articulated in IR, addresses the need to cooperate in solving common problems in the context of a fragmentation of authority and multiplication of actors. Thinking in terms of complex systems can help us identify the contours of a more relevant global international governance system.

This is precisely the aim of this collection of essays, which brings together scholars from various disciplinary backgrounds, based on three continents, with different theoretical and methodological interests but all active in the topic of complex systems as applied to international governance. They investigate how complex systems have been and can be applied in practice and what differences it makes for the study of international governance. Two important threads link all the contributions: (i) To what extent does the complex systems approach offer a promising path toward understanding global governance dynamics? (ii) How can it be implemented in practice? The forum starts with three general contributions that retrace the historical account of the links between complex systems thinking and IR (Peter Haas), suggest a middle-ground approach to adapting complexity approaches to IR (Malte Brosig), and explain how global governance can be studied as a complex system (Philipp Pattberg and Oscar Wideberg). The following two contributions (Jean-Frédéric Morin and Laura Gomez-Mera; Neil Harrison and Robert Geyer) present detailed case studies on international trade and climate change governance, respectively. The last contribution (David Chandler) comes back to the main lessons drawn from the forum and engages in a reflexive discussion on the added value of a complexity perspective. Overall, thinking in terms of complex systems invites us to give up on prediction, to dissociate management from control, to be attuned to unintended consequences, and to rethink the role of power. The world is not a machine, for better or for worse.

IR Encounters Complexity

Complexity is a structural condition of world politics. It provides the ontology behind challenging current research questions. It has been most deeply studied through research on international environmental politics, global change, and the Anthropocene (Crutzen 2003; Biermann 2014). International environmental politics scholars were some of the earliest to describe and understand the broader implications of complexity, in part because of the affinity between ecosystem dynamics and complexity. Moreover, they were among the first to recognize the interconnections between physical and social systems and to study the broader dynamics by which complex global relations are understood and governed.

Complexity involves interconnections between separate areas of activity. While international environmental politics has taken the form of studying how the physical environment and the social environment interact (Choucri 1993) and international political economy studies have focused on the globalization of economic activities (Maddison 2007), complexity studies have merged and complemented both, through our understanding of how economic factors contribute to global environmental disruption (or protection) and the role of global economic activities in a broader context of social, cultural, and ideational globalization.

The recognition and articulation of complexity are rooted in early twentieth century quantum physics (Kern 2003; Wendt 2015). At its core, complexity identifies a set of properties that shape world politics after increasing globalization. Complexity in world politics is therefore generally regarded as a twentieth century phenomenon and as really taking off post-WW2. There are more actors and types of actors than ever before, spanning states, multinational corporations, nongovernmental organizations (NGOs), international organizations (IOs), and expert communities. More issues are on the international agenda, and they are increasingly causally interconnected. Domestic politics and IR are increasingly intertwined. Few shared international norms inform IR, as the post-WWII liberal consensus is increasingly contested (Held et al. 1999; Haas and Hird 2012, preface; Hale, Held, and Young 2013).

While international regimes were widely created after WWII to deal with discrete issues, they progressively failed to recognize or capture the interconnections among them (Mazower 2012; Hale, Held, and Young 2013). To the extent that governance efforts have continued to focus on isolated issues, political constituencies have become consolidated within regimes, and it has become increasingly difficult to build governance arrangements around their interconnections. Scholars who continue to discretely study individual regimes run the risk of reifying the fiction of fully decomposable and disjointed global governance, as well as failing to study the dynamics by which regimes are partially coupled with one another and change occurs.

Many of the analytic features of complexity have also been identified by work on wicked problems (Rittel and Webber 1973) and super wicked problems (Levin et al. 2012). Issues are coupled, although there is uncertainty about the extent of their coupling and with which other issues coupling occurs. Slow change may accumulate with runaway effects, by which time effective responses are impossible, such as with climate change. There is no single source of authority responsible for governing these issues or capturing their interconnections. Unanticipated consequences of actions are common, and surprises are frequent features of world politics. Thus, there is a disconnect between actors' intended consequences and actual outcomes. Moreover, the technical dimensions of issues cannot be disentangled from normative considerations. Consider sustainability. There are multiple possible equilibria for sustainable consumption: the question is how are consumption decisions to be distributed between and within countries. Should everyone be equal, and how should such changes in practices be awarded (Freeman and Jahoda 1978; Agarwal and Narain 1991)?

Robert Jervis (1997) also identified the system effects of complexity in terms of increased uncertainty by decision makers about the nature of the policy environment, their own choices, and the consequences of those choices. Under such circumstances, decision makers operate in a condition of ignorance rather than uncertainty and thus cannot resort to the standard heuristics of insurance and other ways of handling uncertainty (Knight 1921; Iida 1993).

Furthermore, complexity introduced a new level of analysis for IR. Beyond Waltz's three images (1954), complexity introduced a higher order level within which social relations at the international level occur. This is why systems theorists applied similar concepts to that of complexity to study international relations. Morton Kaplan introduced the study of systems theory as a framework and epistemology for world politics research (Kaplan 1957). Oran Young was an early adopter of systems theory to study complex international systems (Young 1968). The research problematique raised by general systems theory is of a set of tightly coupled, irreducible natural and social systems. More generally this ecological view focuses attention on global ecological systems, international political (and social and economic) systems, and their interplay.

Complex systems are more than complicated. Because there are multiple factors and pathways influencing conditions in both social and natural systems, causal analysis is fundamentally overdetermined. Explanations of interesting phenomena require attention to multiple potential causes and interconnections between various forces. Confirmation, validation, and reproduction are often difficult. In particular, because complex systems are often in flux and have emergent autopoietic qualities, it is impossible to reproduce results because the system itself may be constantly changing. Thus, deductive theorizing is extremely difficult. Many authors prefer instead to describe what they deem to be salient transformative systemic processes (Homer-Dixon 1996; Young 2010).

Yet this systems approach is unsatisfying for understanding the dynamics of responding to complexity and its governance. With a single system for analysis, there is no variation, and it is difficult to establish the boundary conditions for various social mechanisms and subsystems. The big view is of a self-correcting global system, where all of the underlying subsystems are mutually constitutive. In such a conception, understanding the sources of change is illusive; change and self-reflection is essential to the system itself. How does an emergent property such as of self-awareness occur? This gives rise to the paradox of how can a system that gives rise to such potential instability also be self-correcting? And if it is not self-correcting, what can be done? At best, using complexity theory as a way to understand the governance of complexity is a deceptive metaphor. Indeed, Earnest and Rosenau (2006, 147) trenchantly observe that "the paradigm of complexity holds greater sway than the theory does." While the implications of complexity for the study of international governance have proven to be illusive, much recent work has focused instead on how complexity is governed.

Currently, most IR scholars study ways by which liberal governance can transcend the original discrete liberal institutions by recognizing the functional interconnections in the international political system and designing or making use of the wide array of overlapping institutional arrangements for those issues. Studies of regime complexes and of orchestration provide a plausible framework for one dynamic by which governance linkages between complex issues are forged. Regime complexes exist for most regimes and create opportunities for policy innovation and strengthened governance, although they can lead to fragmentation and regulatory races to the bottom as well (Raustiala and Victor 2004; Oberthür and Gehring 2006; Alter and Meunier 2009; Gehring and Oberthür 2009; Keohane and Victor 2011; Van de Graaf 2013; Zürn and Faude 2013). The orchestration literature documents the extensive proliferation of joint governance efforts between nonstate actors, coordinated by IOs (Abbott and Snidal 2009; Abbott, Green, and Keohane 2016). Because

of the multiple institutions involved in these complexes, they provide the wherewithal for entrepreneurial actors to draw connections between individual regimes. Private governance institutions offer fluid links between state-based institutions, with IOs serving as orchestrators. To date this literature still focuses on describing the dazzling array of governance arrangements within functional domains and trying to account for their patterns and proliferation. It does not have a credible account for which issues will be linked or by what policy instruments.

Constructivist analysis that focuses on actor networks and agency provides a stronger causal argument as to which linkages will be forged, although it has less to say about how those linkages will be institutionally organized at the international level. Ernst B. Haas noted that the boundaries and nature of complex issues are socially constructed: which issues are causally connected are not perceived “naturally” but rather are the consequence of shared understandings by engaged political actors (Haas 1975). The prospects for linkage and the dynamics of linkage have to do with shared normative and causal understandings (Haas 1980; Haas 2013). This framework for understanding how complex wholes get organized in practice has been fruitfully applied to the Sustainable Development Goals to explain patterns of issue linkage (Haas and Stevens 2017). The epistemic communities’ literature provides a handle to explain how specific actors can contribute to issue aggregation via processes of social learning (Haas 2015).

Finally, pragmatism offers a methodological and causal framework by which analysts, epistemic communities, and policy practitioners may exchange views and learn from one another (Dewey 1929; Haas and Haas 2002; Bauer and Brighi 2009). It provides a dynamic of change by which collective understanding by academics and reflective experience by practitioners are combined and refined, and each group learns from the other. Complexity poses the dominant problematique for contemporary IR that various theoretical approaches are trying to embrace. The most useful approaches have invoked constructivist and institutional mechanisms to account for the growing number and nature of international environmental governance instruments.

Restricted Complexity: A Middle Path between Postmodern Complexity Theory and Positivist Mainstream IR

This contribution brings the application of complexity approaches closer to mainstream IR scholarship. While most of IR research does indeed explore complex phenomena, complexity approaches remain grossly underused or are referred to as a metaphor only. The main reason is very likely the perceived deep division between the postmodern orientation of complexity approaches and the still scientific and positivist orientation of much IR research (see above). However, these divisions are less substantial than one might assume. A middle ground can be found in further operationalizing the notion of *restricted complexity*, which combines elements from the classical scientific approach as well as postmodern ones. It will be illustrated using the example of the African security regime complex.

The argument for a middle ground position is built on the observation that, in many cases, the empirical phenomena of interest are neither fully on the side of the postmodern complexity approach, with its emphasis on nonlinearity and emergence, nor fully on the side of clearly identifiable causal relationships in the original scientific understanding. The questions of what brings peace, democracy, or development are good examples of the in-between location research is often placed in. While we know many causally relevant conditions that bring peace, development, or democracy, research has largely failed to produce an applicable parsimonious universal formula for it. Although the instruments for peacebuilding are widely discussed and tested, the same instrument applied to different conflicts does not

necessarily wield to the same outcome (de Coning 2018). This poses a challenge for both the nonlinear framework favored by postmodern complexity approaches and the positivist research of mainstream IR. Neither will the search for single causes of a complex phenomenon deliver better theories, nor can the fundamental neglect of existing causal relations provide a comprehensive understanding of a research puzzle. Mainstream IR scholarship continues the search for causal relations in order to contribute to theory building, but this takes place in an environment that is rightly perceived to be of increasing complexity.

On the one hand, we can hardly reduce social relations to a single or a few parsimonious variables and place them in a deterministic cause-effect relationship in order to build robust theories from these observations. On the other hand, conceptualizing IR as principally consisting of nonlinear relationships in which actorness is only to be found in the system which is self-organizing and in which no prediction over causal relations can be made does not fully match the empirical world. IR can barely be assumed to be completely free from strategic behavior and hierarchical authority, for example, which rests on the assumption that actors as such have ontological bearing and that certain interests and properties they encompass have causal consequences (see, for example, the literature on rising powers).

If linear thinking and complexity are placed in the two opposing camps of positivist and postpositivist orientations, they are easily identified as simply incommensurate approaches with essentially different epistemological foundations: separating explanation from understanding. However, such a separation is rather artificial. Elements of the linear model can be found in complexity approaches. Even complexity theorists who are fundamentally postmodern in orientation, such as Byrne and Callaghan (2014, 19), do not argue in favor of abandoning “law-focused Newtonian science” but question its universal application. Causality and hierarchy do exist in complexity approaches but have seldom taken center stage for complexity theorists as they aimed at being distinct from the traditional linear scientific approach. Causality is still understood as a cause-effect relationship but is nondeterministic and multidirectional. Complex systems produce “multiple but limited sets of possible futures” (Byrne and Callaghan 2014, 176). In this regard they are causally relevant. Complex systems are also assumed to operate and interact with their broader environment, which is not a priori another complex system. If complex systems adapt to their noncomplex environment, they can be a product of linear processes. The idea that complex systems consist of recurring patterns of interaction (feedback loops) also indicates that traces of causal and linear influence can be found even within such systems (Cilliers 1998, 6).

Lastly, complexity approaches often argue that the system properties are not just the result of a simple addition of its parts. This is true especially in relation to key concepts of the theory such as self-organization, emergence, and nonlinearity. But the system cannot exist without its parts (Morin 2007, 7–8). To some degree, the constituent parts within a complex system are treated as nonreducible entities. They simply do exist. However, the important argument is made that our knowledge of these constituent actors is either incomplete or trivial outside of complex systems. Neither can we understand the system without its parts, nor should we aim at separating the parts from the system. In such a relationship, causality exists but not in the classical linear scientific understanding that treats the cause separate from the effect.

Situations in which the effect impacts on the cause are known as endogeneity and are usually seen as problematic and compromising the search for cause-effect relations. However, within social sciences we should critically ask if universally applicable deterministic independent variables do exist, and if they do not, what is framing their effects? Most likely we may find that they operate within a social context from which they are difficult to separate completely. However, it does not follow from this fundamental observation that the search for causality is generally fruitless.

Table 1. Comparing systems

| Complex systems | Restricted complexity | Linear systems |
|-------------------|-----------------------|-----------------------|
| Open system | Semi-open system | Closed system |
| Nonlinearity | Multiple causality | Linearity |
| Self-organization | Dispersed authority | Centralized authority |

In sum, complexity approaches, even when understood as postmodern approaches are using many elements from the linear school. In the end, it is more a mixture of the positivist and postpositivist schools of thinking than an exclusive representation of only either side.

From a pragmatic perspective, then, how can IR research engage complex social phenomena using key concepts of complexity? While there are good reasons to assume that traditional linear scientific approaches are often too reductionist when exploring complex social phenomena (Jackson 2011), it is also true, according to some authors, that in IR few examples fully fit the postmodern notion of a complex system as described by Cilliers (1998). We are rather confronted with semicomplex issues in which, for example, strategic behavior is played out in a complex environment.

Complexity research has been understood by some as a middle way between more linear positivist approaches and the postpositivist school (Geyer 2003, 244). The notion of restricted complexity is particularly useful in this context because it can be placed between complex and linear systems. It was first introduced by Morin (2007) in contrast to the notion of general complexity, which he saw as remaining within the realm of classical science. Although recognizing complexity, it decomplexifies it (Morin 2007, 6). Operationalizing the notion of restricted complexity can help create a tool for research occupying the middle ground between an ideal type of fully complex systems and a more classical understanding of linear order. In this understanding, restricted complexity operates within a broader nexus between complex approaches and a noncomplex (simple) system. Most IR scholarship is likely to populate an extended space between the two antipodes. Key characteristics of restricted complexity are semi-openness, multiple causality, and dispersed authority (see table 1).

Instead of having a fully open or completely closed system, we are more likely to be confronted with a semi-open system. In such systems, we can identify politically relevant actors to an issue, be they parties, states, IOs, NGOs, etc. However, we may not know beforehand which actors are involved and how. Yet, for analytical purposes it does make a difference whether we are confronted with a limited but large number of actors or a principally unknown or infinite number of them.

Instead of having a system that is nonlinear or linear, we are more likely to be confronted with issues of equifinality (see also introduction to this forum). Equifinality cannot be reconciled with a deterministic understanding of causality, but it still describes causal relations within a scientific framework, such as that of qualitative comparative analysis in the form of necessary and sufficient conditions (Rihoux and Ragin 2009).

Instead of understanding order as a form of self-organization or centralized authority, the concept of restricted complexity offers a richer middle path. Dispersed authority links up with the notion of governance without government. A rich literature on global governance, regime complexity, and overlapping institutionalism already operates with a notion of dispersed authority (Brosig 2013; Orsini et al. 2013; Alter and Raustiala 2018).

While the terms open or closed systems, linearity or nonlinearity, and self-organization and centralized authority describe either/or pairs of relations,

restricted complexity should better be understood as covering the broad area between complex and linear systems. There is ample space for various forms of systems within restricted complexity. It does not define a particular type of organization at the exclusion of another. Thus, we need to explore those conditions that frame restricted complexity. The following paragraphs elaborate scope conditions or demarcation markers linked to semi-openness of the system, the issue of multiple causality, and dispersed authority.

Semi-open systems are those systems that operate with a large but limited number of actors. There are at least three demarcation markers for semi-open systems. First semi-open systems may be large and consist of many actors but can be delimited in terms of their reach or the geographical space in which they operate. In principle, no social system is infinite or completely borderless, but it might entail a high number of actors and issues, which compromises the search for simple solutions to an issue. Second, the semi-openness of the system may also depend on the degree to which the issue the system addresses is linked with other issues. Thus, to which extent can we observe a functional linkage with other (policy) areas? These linkages extend the range of the system but are not infinite. Third, systems are semi-open because the capacity of actors to engage in consequential ways with the issue is limited. The existence of many actors does not necessarily mean they are relevant for the system if they are lacking the critical capacity to address the issue (policy area) toward which the system is aligned.

In terms of multiple causality, the semi-openness of the system can also be linked to the question of linearity. The more open a system, the less likely it becomes to explore and detect causal relationships between actors. The wider the geographical space of operation and the more interconnected the issues, the less likely it becomes to identify clear law-like causal relations. There is, however, a difference between having completely nonlinear or multiple causes for an event. The latter can be explored using a scientific approach; the former is largely incompatible with it (Bennett and Elman 2006).

Dispersed authority is a nonhierarchical form of order, which is decentered and thus can be placed between the hierarchical exertion of authority and self-organization. Issues of global order are neither confronted with a world without authority nor with a central managing body. Authority is dispersed in wide spaces in cases in which it is overlapping (e.g., regime complexes) and in which hierarchies are not immediately clear. Novel issues that have not been regulated before may also fall under the category of dispersed authority, as it is not yet clear where authority is located.

One example of how restricted complexity can be applied is research on regime complexity and peacekeeping. It is ideally located at the crosslines between scholars applying complexity theory (Brusset et al. 2016; Chandler 2016b; Kaufmann 2017) and mainstream IR, which tends to follow a more traditionalist approach to research and causality. As such, regime complexity operates with a large number of actors, the consequences of regime complexity are ambiguous (Alter and Meunier 2009), and regime complexes are decentralized forms of order (Orsini et al. 2013). In other words, this literature does implicitly build on key tenets complexity theory has prominently formulated. However, when taking a second look, it becomes clear that regime complexity does not operate with an infinite number of interacting regimes, that research has explored causal relations (Gehring and Oberthür 2009) and effects (Gehring and Faude 2013), and that order (governance) is a consequence of system qualities as well as individual actors grouped together. In other words, regime complexity occupies exactly the space that restricted complexity is describing.

Let us provide a more concrete empirical example. The international response to larger scale armed conflicts, especially in Africa, can be understood as constituting a regime complex that often leads to the deployment of international peacekeeping

missions, among other instruments of conflict management (e.g., mediation, observer missions, sanctions, etc.). This regime complex is characterized by the existence of numerous actors ranging from the United Nations to the African Union, European Union, and various subregional African organizations (Brosig 2015). International conflict response is not centered on a single actor any longer but dispersed among many. The constellation of actors varies from context to context but usually involves a mix of regional and global IOs. Before a conflict breaks out, it is not fully clear which IO will take what particular action. For example, the UN has deployed missions following regional organizations, together with them, or separate from them. However, the multiplicity of actors and the absence of clearly structured hierarchies or commonly accepted scripts for action does not mean the international response is random or unstructured. In fact, we can observe a division of labor following functional conditions in line with what population ecology has formulated (Brosig 2014).

In other words, neither the conceptualization of regime complexity following a postmodern understanding of complexity approaches as principally open systems with a near infinite number of interconnected actors nor the static assumption of a fixed number of actors with given properties following a scientific model of research adequately captures the situation. The international response to armed conflicts in the form of a regime complex can best be described as a semi-open system in which many actors come together, which limits predictability and thus prevents the building of theories on law-like assumptions. At the same time, the number of actors is not infinite, and actors do follow certain scripts (interests, doctrines, capabilities), meaning that a rational-choice approach can operationalize and be used to predict some behavior.

Within the peacekeeping regime complex, actors do converge (Brosig 2013) and indeed display elements of self-organization—for example, when multiple IOs operate in the same conflict area without having a previously agreed masterplan to do so. Here, peacekeeping becomes the collective and spontaneously coordinated response of a whole group of actors and is more than the individual response of one alone. There is no central steering organ and thus authority is dispersed and decentered. Out of this situation, IOs often set up so called International Contact Groups (ICGs), which have taken on a light steering function. However, the decentered character of ICG authority does not fully equal self-organization because the former implies shared authority, while the latter does not presume to analyze authority that rests on single actorness or groups of them. Actors converge, but this does not mean that they get fully absorbed into a self-organizing system. Instead they do retain autonomy but a conditioned one with strong interdependence.

In the end, the short illustration of the security regime complex is well captured by restricted complexity with its emphasis on semi-openness instead of a fully open or closed system. It describes a situation of multiple causality, but not nonlinearity or linear relations, where authority is rather decentered than centralized or fully self-organized. The notion of restricted complexity was brought up and operationalized in order to map out a middle path. The analytical value of such a middle path is apparent. The greatest value might be that research that does not fall neatly into either category of fully postmodern complexity theory or the mainstream positivist tradition in IR research is not forced to take sides. There is no point in exploring complex empirical phenomena with a toolbox favoring actor-centered causality in an artificially confined environment only to satisfy methodological concerns. There is also no need to fully “convert” and apply postmodern complexity theory in situations in which actors are many but not infinite, where causality plays a role but is not unidirectional, and in which emergence is not only a system function. Ideally, the concept of restricted complexity works as a bridge allowing more traditionally minded researchers to confidently use the terminology complexity theory has

developed, using the term not merely as a metaphor but as a valuable analytical instrument. For those already working with complexity theory, this contribution should be read as an encouragement to widen the applicability of their favored approach. Complexity theory is more than a niche approach; it can enrich IR research both at the meta- and midrange level by breaking old divides in thinking and applied research.

Studying Global Governance as a Complex System: A Network Perspective

To say that contemporary global governance is complex is a commonplace. However, while complexity is frequently used as a qualitative description and metaphor, few authors within IR have attempted to conceptualize and measure complexity taking into account the perspective of complexity approaches. In this contribution, we argue that global governance, as the overall system of rules and regulations pertaining to world politics (see [Dingwerth and Pattberg 2006](#)), has the properties of a complex system and should therefore be described and analyzed through the lens of complexity approaches. In particular, we highlight the role of network analysis and provide a brief illustration from the domain of global forest governance.

According to [Young \(1999, 11\)](#), global governance can be defined as the “combined efforts of international and transnational regimes.” The empirical and conceptual research agenda on global governance (for a more detailed conceptual discussion, see [Dingwerth and Pattberg 2006](#)) has followed this conceptualization in focusing predominantly on international institutions and, to a less extent, transnational institutions (see [Pattberg 2012](#)). The overwhelming majority of scholarship to date has unfortunately studied isolated institutions or ideal-type approaches (such as nonstate market-based governance, see [Cashore 2002](#)), without taking into account the increasingly congested nature of global governance and the many existing interactions and linkages among governance institutions (see [Oberthür and Gehring 2006](#); [Biermann et al. 2009](#) for exceptions). However, if we take “complex interdependence” ([Keohane and Nye 1977](#)) as our empirical starting point, complexity theory seems to be a natural choice for understanding the increased complexity of global governance, from climate change to the financial crisis.

A survey of articles published in Web of Science (WoS) investigates the use of complexity-related concepts in IR. WoS’s journals pertaining to global governance studies—that is, in the subdisciplines of IR, political science, government and law, and public administration—and their corresponding articles (745,998 items in total)¹ were searched for the words “complexity” or “complex systems” in the title, abstract, author keywords, or Keywords Plus® (a special WoS categorization), resulting in 1,966 articles. Narrowing the data-set further by excluding articles using the term “complexity” without mentioning “complex systems,” we found seventy-four articles that included “complexity science,” “complexity theory,” and “complex systems” in the abstracts, titles, and keywords. Considering the large number of articles in the starting sample, this finding suggests that the number of articles using complexity approaches in global governance is fairly limited.

The distribution of publication years in the sample shows that the use of complexity approaches is a recent phenomenon in global governance studies. Whereas the earliest mention of complexity in the dataset is an article from 1982 on forecasting international crises in the *Journal of Conflict Resolution*, only ten articles were published before 2006, meaning that over 85 percent of all articles in the sample have been published in the last ten years. Furthermore, examining the distribution of journals and authorship, there is no indication of a “community” of scholars using complexity science or theory in global governance studies. The seventy-four articles

¹ Search made on 27-28 March 2017.

were published in fifty different journals, with fifteen journals containing more than one article on complexity, and written by one hundred different people, of which twenty-four articles include female (co-)authors (e.g., [Ruth and Coelho 2007](#); [Brachthausen 2011](#); [Cudworth and Hobden 2013](#); [Meissner and Jacobs 2016](#)), with only ten people (co-)authoring more than one article. As [Bousquet and Curtis \(2011, 44\)](#) have aptly phrased it: complexity theory “continues to stubbornly remain on the margins” of IR theorizing.

While the overall impact on the discipline of IR is limited, ideas emerging from complexity science have influenced IR and global governance scholarship along two lines of inquiry: governing complexity (i.e., governance that is appropriate to deal with complex problems) and the complexity of governance (i.e., the complex interaction and interplay among institutions within and across policy-fields). Related to the first usage, debates about adaptive governance and resilience use complexity as a key concept (see [Duit et al. 2010](#)). New forms of governance, including transnational institutions, are seen as a reaction to more complex problems and more interactions among causes and effects. This line of inquiry is interested in governance as a reaction to complex change. In the words of the editors of a special issue for *Global Environmental Change*: “A central question is whether there are certain forms of governance that are better equipped for addressing and managing processes characterized by complex change?” ([Duit et al. 2010, 366](#)). The same reasoning can be found in Young’s recent book ([Young 2017](#)). In sum, a suitable description of this research line would be: *governing complexity*.

The second line of reasoning is concerned with the complex interactions of multiple institutions within and across a policy field; in short, the *complexity of governance* and governing itself are at the center of attention. On this topic, scholarship has been surprisingly silent to date. In the next section, we will therefore discuss how the notion of complex systems can be operationalized to help scrutinize the complexity of global governance with the help of network perspectives. Referring to [Page \(2015, 24\)](#), complexity can be understood as DEEEP: difficult to explain, evolve, engineer, or predict. The complexity of complex systems derives from the relationships among constituent parts, not from the parts themselves. In other words, complex systems are complex because of the interactions of their components and not because of additive effects of all parts. It is therefore not sufficient to map all governance institutions in a given issue area in order to deduce outcomes (the standard approach of regime theory) because interactions among constituent parts result in system-wide emergent properties such as social learning and adaptive behavior (see introduction to this forum). How then can global governance be studied as complex systems? A short-hand answer is: by taking nonlinearity seriously as a key characteristic of complex systems.

Networks are a perfect embodiment of nonlinearity. We contend that network approaches and relational ontologies ([Emirbayer 1997](#)) will feature prominently as analytical tools to unravel complex systems ([Watts and Strogatz 1998](#)). In the words of [Capra \(1996, 82\)](#): “The first and most obvious property of any network is its nonlinearity—it goes in all directions.” Networks as a specific mode of organization (as opposed to markets and hierarchies) have been recognized in IR and global governance scholarship for a while. Examples include [Keck and Sikkink’s](#) concept of transnational activist networks (1998) and [Slaughter’s \(2017\)](#) recent work arguing that we should change our entire perspective of international politics, moving from a “chess board” to a “web” view.

Network analysis as a formal method of inquiry has been applied less frequently, however. This is rather regrettable, as network analysis allows for fine-grained but robust measurements of structure (e.g., interactions among institutions in the climate change regime complex). Network analysis is grounded in three principles that make it an ideal approach within complexity science ([Hafner-Burton, Kahler, and Montgomery 2009, 562](#)): first, nodes (i.e., agents) are behaviorally

interdependent; second, ties between nodes can be channels for resource exchange (material and nonmaterial); and third, repeated and persistent patterns of interaction among nodes create structures that exert influence on the behavior of agents.

In a networked world, it is the position in the network that determines the potential to influence outcomes, not the individual attributes of agents. Hence, to rule in a networked world, one needs tools for appreciating one's position in the network. Network science and network analysis offers a toolbox of various metrics and methods for navigating networks at the local, regional, and global level. At the local level, centrality measures such as betweenness centrality and degree centrality indicate the importance of a single node vis-à-vis other nodes. At the regional level, studying clusters could say something about nodes that tend to form linkages with each other. At the global level, the network topology says something about the overall connectivity of the network, allowing for comparison across various networks. Most of these approaches are developed in disciplines far from IR, such as physics and mathematics, but have turned out to hold true for other disciplines as well. The next step is to introduce it more systematically to the study of global governance.

How can this type of thinking help analyze global governance? What insight do we gain from applying complex systems perspective? We argue that a complex system perspective on global governance helps us realize three important insights: First, complex systems consist of entities. We can operationalize diverse entities as different actors' types (e.g., public, profit, nonprofit). Data from the domain of global forest governance shows that next to governments, the issue-area is governed by IOs, cities, companies, investors, and nonprofit organizations. A total of 6,239 organizations are active in the global forest governance domain (Pattberg, Kristensen, and Wideberg, 2018). Second, in complex systems, entities interact with each other. For global forest governance, we have checked whether entities are interacting with each other by performing a network analysis of overlapping membership in global governance institutions (a network is then created among institutions within and across issue areas for those that share a member). By projecting the two-mode network of institutions and their members to a one-mode network of institutions, we find that only four institutions out of eighty-four are so called "isolates," meaning that they do not share a single member with another institution. Consequently, institutions in the global forestry governance complex form a tightly knit network in terms of overlapping membership. This in turn suggests that the likelihood of ideas, knowledge, and information spreading across the institutions increases compared to a random network with similar numbers of nodes and edges.

Third, complex governance systems show self-organization. Far from resulting in overlaps and conflicts, governance systems display functional differentiation of tasks and instruments. Data from the global forest governance domain show that next to setting standards and commitments, financing, operating and networking, and information-sharing are also performed as dominant functions (Pattberg, Kristensen and Wideberg, 2018).

Studying governance systems (aggregations of regulations, institutions, rules, norms, and decision-making procedures) as complex systems has a number of important implications. First, instead of focusing on individual institutions, attention is directed toward interactions and interconnections—that is, the physical/social nexus between governance approaches. Second, evaluating global governance systems needs to take into account the complexity of the system—that is, system level performance is not the same as additive performance. And third, because learning, adaptation, self-organization, and feedbacks play important roles in complex systems, we need to critically rethink assumptions about top-down steering and "orchestrating" governance.

The Evolution of Governance Systems: The Case of the Trade Regime

The international trade regime has undergone a remarkable and unexpected transformation in recent decades. Studying the trade regime helps shed light on how complex systems evolve at the international level. While Article XXIV of the General Agreement on Tariffs and Trade (GATT) authorized preferential trade agreements (PTAs) under certain circumstances, the latter were viewed as rare exceptions to multilateral liberalization. Yet, since the creation of the World Trade Organization (WTO) in 1995, PTAs have proliferated, and over four hundred of these agreements have been signed. In addition, PTAs are now more far reaching. Some recent agreements include provisions on a variety of issues, such as investment, competition policy, intellectual property and the environment. As a result, the international trade regime now overlaps with several other bodies of international law that were previously quite distinct.

In the early 1980s, scholars started considering trade institutions as a regime (Finalyson and Zacher 1981; Ruggie 1982). The trade regime was recognized as being “complicated,” given the nuanced rules, which were difficult to interpret and apply. The early literature typically focused on the exogenous conditions necessary to create and maintain the trade regime, such as the active investment of a benevolent hegemon. However, early studies on the trade regime assumed it was inert and largely overlooked its complex endogenous dynamics.

Theoretical developments in the IR scholarship on regimes (Raustiala and Victor, 2004) were gradually reflected in research on the global governance of trade. Thus, the existence of interactions and overlaps among a growing number of trade institutions began to be acknowledged. Some studies explain the recent proliferation of trade agreements in reference to “contagion” and the effects of competition between countries (e.g., Egger and Larch 2008; Baccini and Dür 2012). Others focus on the legal content of trade agreements, by examining how specific treaty characteristics are diffused across the network of trade agreements (e.g., Horn, Mavroidis, and Sapir 2010; Milewicz et al. 2016). A third stream of literature examines the interactions between bilateral, regional, and multilateral trade agreements (e.g., Davis 2009; Gómez-Mera and Molinari 2014; Gómez-Mera 2015; Brandi 2017). Finally, scholars have studied the consequences of the overlap between trade and nontrade institutions (e.g., Jinnah 2011; Carneiro 2014; Morin and Orsini 2014).

Despite the growing interest in interactions among trade institutions, few studies approach the trade regime as a complex system.² Much of the literature on the trade regime remains conspicuously agent-centric and ignores system effects. Even studies that use the concept of “complexity” to analyze the governance of trade focus on how overlap and density constrain and shape the strategies adopted by trade negotiators (Davis 2009; Meunier and Morin 2014). Little attention has been paid to the many unexpected consequences of the interactions and their effects on the evolution of the trade regime itself. While the focus on agency is extremely valuable for understanding the governance of trade, it leaves some important—more holistic—questions unanswered.

Is the trade regime a complex system? The introduction to this forum argues that a complex system displays four characteristics: it includes multiple units of various types, these units are intricately interconnected, they operate at different levels, and they constitute a system that is open to its external environment. The trade regime has all four characteristics.

First, the trade regime is made up of elements of various types. It includes WTO multilateral agreements and hundreds of PTAs (Dür, Baccini, and Elsig 2014). The scope of these agreements varies in terms of the depth of economic integration. They can be partial, for example, when arrangements are limited to a specific industrial sector, or comprehensive, which is the case for common markets that share

² One exception is Morin, Pauwelyn, and Hollway (2017).

a single currency and common regulatory bodies. PTAs also vary in terms of their level of institutionalization. Some rely on intergovernmental arrangements, while others delegate competencies to supranational agents. A multitude of government officials, businesses, and civil society actors interact through and around these institutions.

Second, these elements are deeply interconnected and interdependent. Trade institutions are held together by a shared set of liberal principles and objectives, which were first laid out in the GATT of 1947. When compared, trade agreements present a degree of coherence, despite significant differences in their design and their impressive proliferation. This is largely the result of dense social and political links among the elements in the system (Wolfe 2005; Pauwelyn and Alschner 2014). For example, Solis, Stallings, and Katada (2009) argue that policy emulation among like-minded elites contributed to the spread of trade agreements in the Pacific Rim. These trade agreements are linked and have formed a network structure. Figure 1 shows the evolution of the PTA network. Each node represents a country and each connection represents a PTA between countries. Research has revealed that this evolving network structure influences the ways in which countries interpret existing agreements and negotiate new ones. According to Lee and Bai (2013), “transitivity” and “homophily” dynamics in the network of trade agreements explain why countries tend to join PTAs.

Third, the structure of the trade regime has multiple levels. The actors and institutions in the trade regime occupy a series of interrelated levels—multilateral, regional, and bilateral. In addition to this geographical structure, a legal structure differentiates among macro principles, meso norms, and micro rules. The dynamics at one level, such as proliferation, competition, diffusion, innovation, or concentration, affect the dynamics at different levels of organization (Kim and Manger 2017). This applies to both the geographic and legal scale. For example, competition between two regional blocs might favor the proliferation of bilateral agreements concluded by the two blocs with third countries. Likewise, the competition between alternative norms, setting out how science should inform trade policy, can lead to the proliferation of detailed rules governing sanitary restrictions on food products.

Finally, the trade regime is open to its environment and interacts intensively with other systems. One prominent example is the gradual imbrication of the trade and investment regimes. As Puig (2014, 493) states, “What had been relatively clear distinct regimes are now blurring, forming an emerging international economic law ‘regime complex.’” With the convergence of the trade and investment regimes, the public and private enforcement of international economic law has become increasingly entangled. Recent trade agreements contain “hybrids” of public and private enforcement, allowing multiple actors to “interact within complex ecologies of adjudication.” (Puig 2014, 493) In this sense, the trade governance system (including PTAs linked by partly overlapping membership) coevolves with the broader global economic system (including firms linked by various types of transaction and ownership). Positive feedback between the system of governing institutions and the system of governed actors increases returns and stimulates their respective growth.

The trade regime also displays the three properties of complex systems identified in the introduction, namely self-organization, emergence, and adaptation. The trade regime is a self-organizing system. The wide range of actors and institutions involved in trade governance interact without any central hierarchical coordination. While the WTO plays a certain orchestrating role, it remains a “member-driven” organization. The rules governing trade relations emerge from negotiations between governments, often with input from private and technical actors. The governments do not even notify the WTO systematically of their PTAs, despite the requirements of the GATT Article XXIV (Mavroidis 2011).

The second property of complex systems, emergence, refers to the unexpected systemic outcomes resulting from the interactions between the units in the system.

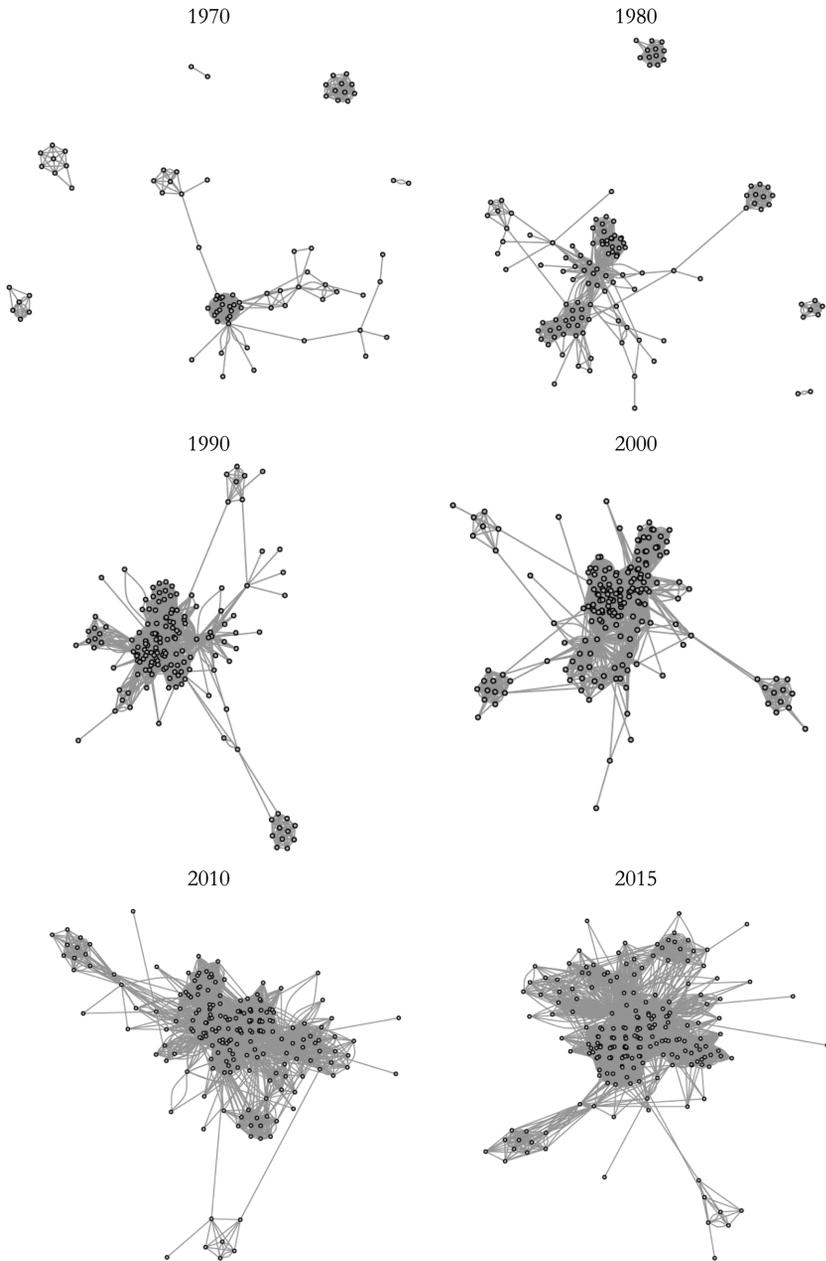


Figure 1. Evolution of the PTA Network Structure.

Source: Authors, with data from [Dür, Baccini, and Elsig 2014](#)

The trade regime has directly contributed to the emergence of economic globalization, a feature that is not only greater but also different than the sum of the parts of the trade regime. The depth of integration and interdependence achieved over the past seventy years would have been hard to envisage in 1947, when the GATT was concluded. Yet, by reducing national trade barriers, the GATT and the first PTAs have had an important impact on the nature of international production, as well as investment patterns ([Orefice and Rocha 2014](#)). They have led to the

contemporary increase in the trade in services, the growth in investment flows, the development of intra-industry and intrafirm trade, the creation of complex chains of suppliers, and the expansion of transnational firms. These radical transformations are so profound that new measurements and concepts are required to make sense of the emerging trade realities. For example, most experts now consider that the notion of “trade surplus” is an obsolete measure of national economic performance, whereas the concept of “global value chains” now reflects the need to modernize the trade regime (Baldwin 2014).

These shifting patterns in international trade have led to adaptive reactions in the trade regime, the third property of complex systems. The early multilateral and regional trade agreements primarily focused on the exchange of market access and facilitating the exchange of end products. These agreements generated a significant expansion in trade. In turn, this has created new incentives and additional regulatory pressures—a feedback loop—with implications for the coordination and harmonization of various behind-the-border rules. In response to this, recent PTAs provide a much deeper level of integration, with detailed chapters on service liberalization, regulatory cooperation, labor mobility, telecommunications, competition policy, financial regulations, intellectual property, investment protection and public procurement. It is clear that the number and scope of recent PTAs go far beyond what was anticipated when Article XXIV was drafted in 1947 (Chase 2006).

These properties—self-organization, emergence, and adaptation—create endogenous dynamics. One key insight of complexity theory is that complex systems evolve at the edge of order and chaos. As mentioned in the introduction to this forum, reinforcing positive feedback makes complex systems particularly sensitive to their initial conditions. Joost Pauwelyn provides examples of such path dependency in the trade regime. He states that the initial articulation of “national treatment” and the old notion of “fair and equitable treatment of foreign investors” have become the dominant standard in international economic law. He goes on to explain that network externalities favor these standards over newly introduced clauses, even when alternative clauses are clearly more suitable (2014, 414). However, complex systems also have negative feedback loops. Unexpected trade disputes, disguised trade restrictions and social contestation have all contributed to the introduction of additional safeguards in trade agreements, notably with regard to investment liberalization and environmental protection (Morin and Gagné 2007; Morin, Pauwelyn, and Hollway 2017). This combination of positive and negative feedback makes complex systems unstable and makes it impossible to predict exactly how they will evolve.

When it comes to analyzing the trade regime, the only reasonable prediction that complexity theory can provide is that endogenous negative and positive feedback will continue to make the trade regime increasingly more complex. Complexity theorist Stuart Kauffman believes that complex systems have the propensity to grow endogenously in their complexity. He suggests that this feature could be a candidate fourth law of thermodynamics (2000, 142). Although Kauffman is referring to the biosphere, other complexity theorists have shown that governance systems display similar autopoiesis: nonlinear interactions between existing elements generate new elements, making the system more complex (Teubner 1993; Luhmann 1995).

In this perspective, complexity is a continuous not a dichotomous variable. Complexity is often considered to be either present or absent in a system. However, it can be conceived as a continuum and measured along various dimensions corresponding to the characteristics of complex systems: the number and diversity of units, the density of their interconnections, the multiplicity of scales, and the degree of interactions with the external environment. Presumably, a certain threshold is necessary on each of these dimensions for a system to be sufficiently complex to exhibit the properties associated with complex systems—namely, self-organization,

emergence, and adaptation. However, even when the threshold is reached, complex systems tend to continue to grow in complexity.

This is the case for the trade regime. It reached a threshold in the early 1990s and has been exhibiting complexity properties since then. It was around that time that trade institutions started to proliferate exponentially. They are also becoming increasingly diverse, with the emergence of new institutional forms, such as plurilateral sectoral agreements (e.g., the Anti-Counterfeiting Trade Agreement), routinized trade summits (e.g., the India-Brazil-South Africa Summits), venues for regulatory agencies (e.g., the International Competition Network) and collaboration between intergovernmental organizations (e.g., the Standards and Trade Development Facility). The trade regime has expanded geographically. A growing number of countries are involved, through multilateral, intra- and extraregional agreements, which have intensified the interconnections between trade institutions. Finally, the trade regime continues to interact with other international regimes. And as mentioned above, recent PTAs commonly include full-fledged chapters on non-trade issues, such as environmental protection, labor standards, and human rights (e.g., [Horn, Mavroidis, and Sapir 2010](#); [Bruhn 2014](#); [Milewicz et al. 2016](#)).

The claim that complex systems grow in complexity is not a deterministic prediction but a probabilistic one. Rich ecosystems have turned into deserts and vibrant cities have shrunk. Likewise, previous trade systems have collapsed, and the current trade system is not immune to this risk. Yet, it is reasonable to expect that: the number of PTAs in force will increase, new institutional forms will emerge to regulate supply chains, the WTO will continue to expand its membership, and the average trade agreement will come to cover additional issue-areas, such as taxation or data security.

The increasing complexity of complex systems and, more generally, their constant evolution, encourage trade analysts to take the temporal dimension more seriously when it comes to studying trade institutions. While history is a dimension that is absent from several disciplines, ranging from Newtonian mechanics to classical economics, it cannot be ignored in complex system analysis. Negotiating a trade agreement in 2019 is difficult to compare with negotiating GATT in 1947. Therefore, causal explanations and mechanisms may not be applicable in different contexts. While it is illuminating to study and identify patterns in social and international dynamics, it is important to acknowledge contextual effects. Complexity theory warns trade analysts against the relentless search for universal and timeless causal explanations.

Another useful lesson for trade analysts is that the resilience of the trade regime does not depend solely on the WTO. The trade regime is populated by hundreds of institutions, which means that the fate of one institution does not determine the evolution of the entire system. In fact, complexity theory suggests that units that are not central can have disproportionate and unexpected effects through nonlinear systemic change. Arguably, the 1957 Treaty of Rome and the 1992 North American Free Trade Agreement had this kind of butterfly effect on the entire trade regime. Instead of being overly concerned with the WTO stalemate, trade policy analysts should examine whether the appropriate feedback mechanisms are in place to ensure that trade negotiators can learn continually from institutional experiments in various parts of the world, at bilateral and regime levels.

In sum, complexity approaches provide a series of illuminating insights into the evolutionary dynamics of the global governance of trade, complementing traditional agent-centric IR approaches. The latter focus on actors' incentives and capabilities and, thus, cannot fully account for the features and patterns of evolution observed in trade institutions. Most of the trade regime's expansion was driven by state actors' deliberate decisions. However, their choices have had significant unintended consequences, which have led to unexpected outcomes. By considering the trade regime as an open, living system, composed of interdependent and

interacting elements and self-adjusting actors, complexity approaches can make useful contributions. They reveal systemic reverberations, emergent properties, and unexpected effects, thus, shedding new light on some aspects of the recent evolution in the trade regime.

The Complexity of the Governance of Climate Change

The influence of human activities on the global atmosphere is “clear and growing” and is anticipated to change local climates across the world with “severe, pervasive and irreversible impacts for people and ecosystems” (Pachauri and Meyer 2014, v). Under the United Nations Framework Convention on Climate Change (UNFCCC), countries have accepted “common but differentiated responsibilities and respective capabilities and their social and economic conditions” (UNFCCC 1992) to collectively “holding the increase in the global average temperature to well below 2°C above pre-industrial levels” (UNFCCC 2016). Because the climate system is complex and, despite extensive and long-term research, the exact nature of these impacts is uncertain, governance of the social response is necessarily complex.

Due to its ubiquity, climate change suggests a global multilevel response. However, national governments and IR scholars continue to focus primarily on an intergovernmental response. The most recent large-scale move in the intergovernmental politics of climate change, the Paris Agreement, is by some accounts “a political success in climate negotiations and traditional state diplomacy” because the arguments during the negotiations were sufficiently persuasive on the economic benefits to induce cognitive change (Dimitrov 2016). It also offers a “new hope” for climate governance because it institutes a “bottom-up” approach (Bodansky 2016).

There is little evidence that the political success in Paris will prevent dangerous warming. For most developed countries this would require greenhouse gas (GHG) emissions reductions of up to 80 percent below 2005 levels. Achievement of such national targets volunteered as a result of the Paris Agreement depends on how firms, municipalities, and individuals are persuaded to accept short-term economic costs for a possible long-term benefit. While there is dispute over the changes that are required, for governments to enforce the necessary behavioral changes on organizations and individuals would appear to require massive intervention in the economy and society, as technological innovation alone, even assuming effective diffusion of innovations, will not suffice (Harrison and Mikler 2014). Avoiding dangerous climate change will require complete decarbonization of electricity production with rapid expansion of electric energy production, costly decarbonization or eradication of liquid fuels, and substantial changes in land use (IPCC 2014). Such changes may cause estimated losses of between 3 and 11 percent of global GDP per capita. In addition, estimates of the cost and effectiveness of mitigative policies are highly uncertain, preventing design of effective long-term policy trajectories.

Depending on nation-states is at best a partial strategy. Conventionally, states choose their actions in the context of international norms and domestic political and economic conditions and implement them from the top down. This assumes that they will be willing and able to implement effective policies and to maintain them over time. The weakness of this position was blatantly demonstrated by the actions of President Trump, who removed the United States, the world’s second largest emitter of GHGs, from the Agreement. In Paris the Obama Administration had proposed a 26–28 percent reduction in GHG emissions below 2005 levels by 2025. According to President Trump, this was too costly and the science was unproven, so withdrawal was necessary “to fulfill my solemn duty to protect America and its citizens.”³ In contrast, China enthused that the Paris Agreement “is fair and

³“Statement by President Trump on the Paris Climate Accords,” WhiteHouse.gov, June 1, 2017, accessed April 1, 2018, <https://www.whitehouse.gov/briefings-statements/statement-president-trump-paris-climate-accord/>.

just, comprehensive and balanced, highly ambitious, enduring and effective, and with legally binding force.”⁴ Although it has made major environmental strides, it still faces major implementation problems. Achieving its voluntary national emissions reductions goals depends on implementation by relatively autonomous regional governments and is fragmented, driven by local social, economic, and environmental conditions.⁵ Some regions are in a “race to the bottom,” implementing only the minimal changes permitted by Beijing (or less), while some cities (e.g., Shanghai) and regions are in a “race to the top.”

The “new hope” in the Paris Agreement is its rejection of enforceable national targets and timetables in favor of a process that allows states to voluntarily set GHG emissions reduction goals and their progress toward those goals. This process still leaves the responsibility for meeting emissions goals at the state level, and many states will choose to use authority in a top-down manner to elicit behaviors by organizations and individuals that will be effective in reaching the chosen emission goals. As discussed below, a complexity perspective suggests that a distributed approach at all levels of social aggregation would be more effective at both meeting mitigation targets and protecting human society.

For a system to be a complex *adaptive* system, it must have an environment to which it must adapt (Mitchell 2009). Defining the system to be studied defines its environment and vice versa. The environment within which the complex conflicts of the Middle East develop includes the international political and security systems but also the historical, religious, cultural, geographical, and resource differences between the players. The true success of the UNFCCC process has been construction of an ideational environment within which complex local social systems may choose their adaptive behaviors.

All significant social systems, from local to global, are complex but different from the natural systems that are often used as exemplars (Boulton et al. 2015). While governments exercise some authority that may simplify decision-making, they may be unable to reduce complexity in the social system being administered (Innes and Booher, 2010). This is because humans have a reflective social complexity that enables them to switch between multiple identities as they adapt to changes in context and sometimes to changes in the rules of the system that orders their interactions. This level of complexity is amplified at the global level not only by the larger physical and biological interactions but by the enormous diversity of human organizational forms and competing interpretations, understandings, and norms on almost any issue (Mitleton-Kelly, 2015). Thus, from a complexity perspective, the true benefit of the Paris Agreement is not seen just in the decisions of nation-states—the “political success”—but in the number of US states and cities that individually and collectively affirmed the Paris goals after President Trump repudiated that agreement. Twelve states representing 30 percent of the US population, 210 cities, and “[m]ore than 1,000 U.S. governors, mayors, investors, universities, and companies joined the ‘We Are Still In’ campaign, pledging to meet the goals of the Paris agreement” (Nuccitelli 2017). These entities chose actions contrary to national preferences because of the ideational environment structured by the UNFCCC process.

Because both social and natural systems evolve, global governance is exceptionally complex, and a political success in intergovernmental negotiations is entirely inadequate. The problem is to manage the coevolution of a global social system and the climate so as to avoid dangerous changes in global and local climates. Simply put, while we are changing the climate, we must adapt our lives to reduce those changes and at the same time adapt to them as they occur. Effective mitigation to achieve global goals set at Paris is most likely to emerge partly from national responses but perhaps more from local choices within the ideational environment

⁴ China’s Closing Statement at COP21, December 12, 2015, quoted in Dimitrov 2016.

⁵ Personal conversation with Professor Wei Shen, Lancaster University.

that it represents. However, adaptation to climatic changes must emerge locally in response to local conditions and resource constraints.

Adaptations by complex social systems may or may not be effective. A social system that is successfully able “to adapt or even transform into new development pathways in the face of dynamic change” is said to be “resilient” (Folke 2016). Resilient social systems adapt to climate change by reducing their net GHG emissions to mitigate global warming and by conserving essential physical, social, and cultural infrastructure in the face of climatic changes as they occur. Social system actions may also be maladaptive, reducing resilience, leading to system collapse despite the significant expenditure of energy and resources (Tainter 1988). The difficulty of designing effective policies increases with the size and complexity of the social system and, because both social systems and the climate are complex and dynamic, it is not possible to assure in advance that any adaptive effort by a social system will be effective. Uncertainty, experimentation, and feedback loops are all part of the process.

Complexity has clear linkages to elements of pragmatist philosophy (Ansell and Geyer 2016) and the debates on governance and policy (Duit and Galaz 2008). Both complexity thinking and pragmatism stress the importance of “evolutionary learning” and “democratic experimentalism” (Ansell 2011, 5) and the need for caution and avoiding hubris when attempting to govern complex systems. Complexity and governance (or multilevel governance) share the idea that for most issues there is no central controlling government. Instead, governance takes place, “through processes and institutions operating at, and between, varieties of geographical and organizational scales involving a range of actors with different forms of authority” (Duit and Galaz 2008, 318). In considering how to intervene in complex collectivities—to modify norms, rules, institutions, or practices—governance actions must recognize that the past does not foretell the future, that unintended consequences may be significant, and that, therefore, the system cannot be firmly, or hardly, “managed” to a desired future state.

An example of one of the tools of pragmatic complex governance would be the use of “catalytic probes”—small scale, low risk experiments intended to elicit information about system response—in order to find small interventions that may cause large scale, positive changes in a system. Each probe into a local social system is a sociopolitical intervention that tests its behavioral response and the consequent emissions reductions in search of an effective contribution to the Paris goals. Spurred by the ideational environment constructed by the UNFCCC and IPCC reports, many regional, state, or local mitigation and adaptation processes have emerged across the United States (Lutsey and Sperling 2008) and around the world (Bulkeley and Castan Broto 2014). By their nature, the probability that such localized probes would unintentionally cause large negative changes in social or natural systems is minimal. In contrast, the risks of geoengineering the complex global climate are, from a complexity perspective, orders of magnitude greater.

Adaptation to changing climatic conditions inevitably occurs locally, subject to changes in local climates, and may be behavioral or physical (UNFCCC 2016). For example, New York and New Orleans may need physical protection from sea level rise and hurricanes. Because farming states in the US Midwest are threatened by prolonged droughts punctuated by serious flooding, behavioral change in farming practices is slowly emerging that reduces emissions and protects productivity (Tabuchi 2017). Elsewhere small-island states, for example, face an existential threat from sea-level rise and have few resources, since developed states have not fully funded their inadequate promises through the UNFCCC financial mechanism (Pickering, Jotzo, and Wood 2015).

Climate change is a potentially catastrophic, nonlinear evolution of a complex natural system caused by human activity. The mitigation of this human activity is complicated by an international system that lacks a central government and where state compliance with international rules and norms is now voluntary. States are

themselves more complex than usually accepted. Thus, if a complex system comprised of multiple complex subsystems can be expected to mitigate changes in a complex natural system, governance processes that emerge across all scales of collectivities need to be coordinated—a form of pragmatic complex multilevel governance. Complexity highlights the need for coevolution of states and between their subsystems in terms of technical knowledge, and physical and financial resources.

From a complexity perspective, effective coevolution of global society with a non-dangerous climate requires more than voluntary agreements among states. Indeed, some states appear to be a major impediment. While this may not be true for all issues, effective global climate governance and more resilient social systems can emerge through action at lower levels of social aggregation than nation states. However, for this to occur resources will need to flow to the most promising local catalytic probes. Thus, states are part of the problem as well as of the solution, and IR theory and thinking must adapt accordingly. Nothing in complexity guarantees that humanity will be able to create a sustainable response to this potentially cataclysmic change, but progress to that end requires probing the workings of an approach better suited to the challenge of global governance through global sharing of effective local strategies and the distribution of resources across all sizes and types of social systems.

Conclusion

This forum starts by explaining that the problem posed by complexity is that it is precisely contemporary developments in science and technology that appear to reveal the limitations of traditional frameworks of policy-making, which are reliant on universal assumptions of cause-and-effect: “Paradoxically, as our tools to make sense of and control societies and our environment increase, our ability to do so diminishes” (Introduction). The importance of complex systems analysis for international governance is precisely that it seeks to enable governance in a world where the impacts of policy-making seem much less predictable and contingent on unknown variables of interaction. The contributions on the problems of climate change and global warming emphasize that while not every question of the international may be complex, the most pressing problems of our contemporary age are ones that necessitate a serious engagement with complex systems of ecosocial interaction.

It is important, however, to realize that the science of the study of complex problems—of emergent causality and of nonlinear effects—is in its infancy. It is easy enough to deal with complex systems in the abstract, for example, by defining the characteristics of a complex adaptive system or outlining the nested hierarchy of interacting systems along the lines of Gunderson and Hollings’ “panarchy.” (2002) It is much more difficult to deal with (and perhaps even to fully recognize) complex systems in real life. Perhaps the key barrier in the field of IR, when addressing the governance of complexity, is precisely the desire to “systematize” the analysis, squeezing real life appearances into the abstract system theoretic frameworks. Even when this is achieved, it is by no means straightforward to advise how to engage with a complex system, especially if it is assumed that any interventions to impact one of the variables may not have a similar impact if the contextual interactions with other variables are constantly evolving. It seems highly likely that the reason complex system analysis remains underrepresented in the IR field is that it can appear to lack a concrete policy program beyond the advocacy of greater caution and humility and a general sense of lowered expectations with regard to policy successes.

That said, there is little doubt that complex systems approaches have become increasingly influential in the field, perhaps one could say, almost by default, as policy-makers move away from traditional “top-down” policy understandings, seeking to follow environmental and contextual “cues” rather than to impose a governing agenda on a world that seems to be growing in its intransigence. One first

indication of this shift is the increasing awareness of our entangled relation to policy problems and threats—that is, that problems are not external to us but, like climate change and global warming, are much closer to home. The less distinction is made between the security referent (that which needs to be secured) and the perceived security threat, the less relevant become the static systems analyses which seek to secure system equilibrium. Thus, understanding complexity in terms of an applied theory for scientific “problem-solving” misses precisely the point that separations between governing actors and problems to be governed are much less obvious than for traditional IR theorizing.

Recognizing that policy-actors are always and already in the middle of complex systems of interaction, contributions by Peter Haas and Malte Brosig provide important illustrations of how complex systems analysis contributes to managerial knowledge, seeking sustainable solutions or the balance between competing normative concerns. Here feedback loops and processes of interaction facilitate projects of process-tracing, enabling the constitution of communities of concern and greater contextual awareness. Management thereby becomes divorced from processes of external or “top-down” control: complexity approaches increasingly place the theorist inside the problematic rather than outside, thus theorizing (and governing) becomes a recursive or iterative learning process. One good example of the power of complex systems analysis has been the response to Hurricane Katrina. As Ulrich Beck argued (2015, 80), an awareness of the interactive and emergent causality of complex systems meant that rather than seeing the flooding and its consequences as being an arbitrary or external “act of Nature,” connections were made between environmental management, racial exclusion, and economic inequalities. This awareness of interconnectivity and the unintentional side effects of previous actions then provided the potential for recursively developing new policy approaches. Governing in complexity thereby becomes an ongoing process of responding to the (unintended and unforeseen) effects of previous actions.

In the following essays, the importance of the complex systems approach for the analysis of international governance is further drawn out. The examples of trade and of climate change illustrate the growing appreciation of the gap between actor intentionality and policy outcomes. Complexity approaches seek to overcome this gap by making governance more process-like, essentially by bringing governance closer to the problem. This approach can also be seen in many attempts to respond, increasingly in real time, to problems in the international sphere—from conflict to environmental crises, humanitarian emergencies, crime, and terrorism. Here, it is suggested that rather than attempting to prevent problems before they occur or merely reacting after the event is passed, awareness of complex systems and emergent causality require a greater level of monitoring and sensitivity to see problems and threats less as emergencies or sudden events but more as processes that happen over time. In the humanitarian sphere, the study of complex processes of interaction has meant that “slow-onset” emergencies are increasingly the focus of attention, where multiple variables are used as indicators of community vulnerability. Similarly, conflict, virus outbreaks, and environmental disasters can be “slowed down” by greater sensitivity to their emergence, especially through the use of new digital and sensing technologies, which can pick up on ecosocial changes to enable much more rapid responses to potential problems (Jacobsen 2015; Kaufmann 2017; Hardt 2018).

In these frameworks, complex systems analysis enables policy-makers to take the emphasis away from the linear and reductionist framings of preemptive “prediction” and post hoc “solution.” Understanding problems and crises as emergent processes has increasingly enabled governance to operate on the basis that problems cannot be effectively prevented or solved but that they can be managed in order to ameliorate their effects. Policy framings, which seek to be more sensitive to contexts and to changing relations, enable new ways of understanding

management at the level of the modulation of effects rather than addressing causes (Chandler, 2016a).

Complex systems analysis thereby informs governance but without the modernist assumptions of the capacity for causal knowledge and predictive possibilities. Thus, new approaches focus upon the “what is” of the world, developing responsive and sensing forms of real-time regulation (see Chandler 2016b, 405–6). This approach, which attempts to grasp complex and plural forms of emergence, has been the subject of several high-level international initiatives, involving the collaboration of leading global agencies—examples include the World Bank’s Open Data for Resilience initiative (OpenDRI), seeking to track the impacts of climate change and the emergence of natural hazards in real time; the PopTech and Rockefeller Foundation initiatives on community resilience and big data; and the United Nations’ Global Pulse, established by the UN secretary-general to research and coordinate the use of big data for development (Chandler 2016b, 406). These initiatives highlight the many ways in which data-led understandings of adaptation are displacing policy interventions based upon traditional understandings of linear causality.

This shift to the adaptive modulation of the status quo (often linked to discourses of resilience and self-responsibilization) has been criticized for lowering transformative expectations and increasingly enabling states and international institutions to affirm or to naturalize existing inequalities and incapacities (see, for example, Chandler 2014; O’Malley 2011; Rose and Lentzos 2017; Duffield 2018). It seems clear that much work needs to be done if a balance is to be struck to ensure that complexity approaches do not become merely an apologia for lower expectations of governing interventions. Nevertheless, the genie of complexity thinking cannot be put back into the bottle and, as the contributions to this forum illustrate, complex systems analysis has already become an important addition to the tool kit of international governance. At the very least, the understanding that we are all always and already entangled in complex systems enables a range of new and innovative policy responses that seek to be more reflective (and also more reflexive) with regard to both contemporary and previous policy interventions as their consequences (both intended and unintended) stick with us. This, in itself, is already of great potential importance.

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