



The emergent network structure of the multilateral environmental agreement system



Rakhyun E. Kim ^{a,b,*}

^a Fenner School of Environment and Society, The Australian National University, Australia

^b Institute of Advanced Studies, United Nations University, Japan

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ABSTRACT

The conventional piecemeal approach to environmental treaty-making has resulted in a ‘maze’ of international agreements. However, little is known empirically about its overall structure and evolutionary dynamics. This study reveals and characterizes the evolving structure of the web of international environmental treaty law. The structure was approximated using 1001 cross-references among 747 multilateral environmental agreements concluded from 1857 to 2012. Known network analysis measures were used to answer the following questions: has a complex system of international environmental treaty law emerged? If so when, and what does it look like? What are its topological properties? To what extent is the institutional complex fragmented? The network analysis suggested that multilateral environmental agreements have self-organized into an interlocking system with a complex network structure. Furthermore, the system has defragmented as it coevolved with the increasing complexity and interconnectivity of global environmental challenges. This study demonstrates the need to approach multilateral environmental agreements in the context of a complex networked system, and recommends against assuming the overall institutional structure is fragmented. Proposals for global environmental governance reform should pay attention to this network’s emergent polycentric order and complexity and to the implications of these features for the functioning of the multilateral environmental agreement system.

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1. Introduction

It is generally accepted that a *de facto* ‘system’ of international environmental law and governance has emerged (Freestone, 1994; Boyle and Freestone, 1999; Najam et al., 2004; Bodansky, 2006). This acknowledgement stems from the observation that international norms and institutions do not exist in isolation but as embedded in a maze-like structure (Young, 1996, 2002). However, we know little about the macroscopic structure and evolutionary dynamics of this system (Biermann and Pattberg, 2008; Young, 2010a). Our understanding has not advanced much beyond ‘congestion’ and ‘fragmentation’ rhetoric based on anecdotal evidence (Ivanova and Roy, 2007). There is a clear need to study the system empirically and *in toto*, and unravel this alleged institutional maze. Such an understanding of the emerging complexity would prove useful in improving the alignment between the governance system and the multifaceted challenges

of governing the interactions of different Earth system processes (Rockström et al., 2009; Walker et al., 2009; Galaz et al., 2012; Nilsson and Persson, 2012).

This study fills the knowledge gap by revealing and analysing dynamic patterns in the structural organization of international environmental law and governance. I take a network-based approach, which uncovers the underlying system architecture by reducing the system to an abstract structure capturing only the basics of connection patterns between its components (Newman, 2010). The core analytic unit is neither the whole system nor individual components, but rather the *relation* between components that gives rise to large-scale connection patterns. The emergent patterns are then treated as mathematical objects or graphs, and analyzed with network metrics such as modularity, clustering coefficient, and average path length. These topological properties reflect differences in the governing system structure that may lead to significant differences in governance processes and outcomes (Bodin and Crona, 2009; Orsini et al., 2013).

For constructing a network representation of the institutional structure of international environmental governance, I chose multilateral environmental agreements as nodes and their cross-references as links that define the relation between the agreements. Multilateral environmental agreements are treaties,

* Correspondence address: United Nations University-Institute of Advanced Studies, International Organizations Center, 1-1-1 Minato Mirai, Nishi-ku, Yokohama 220-8502, Japan. Tel.: +81 45 221 2300; fax: +81 45 221 2302.

E-mail address: rakhyunkim@gmail.com

conventions, charters, statutes, or protocols between three or more governments relating to the environment (Mitchell, 2003; Carruthers et al., 2007). They typically include cross-references to a number of other such agreements that their parties consider relevant. According to Kiss and Shelton (2007), these cross-references can be viewed as extending the legal effect of cited texts to the texts that cite them.

I selected a list of 747 multilateral environmental agreements concluded between 1857 and 2012, and identified 1001 cross-references to other agreements in the list. Using this dataset, I produced a series of agreement-level connectivity maps of international environmental treaty law. I investigated the structural dynamics of the network by focusing on the following questions: has a complex polycentric system emerged among multilateral environmental agreements through self-organization? If so, when, and what does it look like? What are its topological properties? To what extent is the institutional complex fragmented?

The questions relating to the dynamics of the network, that is, how the functioning of the system depends on its topological properties, are beyond the scope of this paper. Such an enquiry would require representing each multilateral environmental agreement as a dynamic system in itself (Churchill and Ulfstein, 2000; Brunnée, 2002, 2012; Gehring, 2007; Wiersema, 2009; Young, 2010a, 2010b) and further specifying the causal mechanisms of institutional interaction (Young, 2002; Gehring and Oberthür, 2009). As the institutional citation network is an abstract representation of symbolic relationships, it is yet unclear how its network measures such as modularity should be interpreted with respect to their consequences for some process on the network. Nonetheless, where possible, explanations were offered by juxtaposing the observed structural changes with what had actually happened in the real world.

The paper starts with a brief review of relevant literature to which the present network analysis contributes. The methods section then follows, explaining what cross-references mean in the context of multilateral environmental agreements and how the data were collected. Key empirical findings are presented in two sections focusing respectively on the evolution of network topology from 1857 to 2012, and static topological properties of the network in 2012. I conclude by identifying implications of the analysis of this structure for governance outcomes.

2. Fragmentation, polycentricity, and networks

Institutional fragmentation has received significant scholarly attention as a macroscopic feature of international environmental law and governance (e.g., Doelle, 2004; Stephens, 2007; Carlarne, 2008; van Asselt et al., 2008; Biermann et al., 2009; Boyd, 2010; Scott, 2011; van Asselt, 2012; Zelli and van Asselt, 2013). Although there is no consensus on its meaning and implications (Biermann et al., 2009; Zelli and van Asselt, 2013), the underlying idea can be traced to the notion of treaty congestion (Brown Weiss, 1993; see also Hicks, 1999; Anton, 2012), that institutional proliferation has led to chaos and anarchy.

From a polycentric perspective, however, “fragmentation at the international level does not imply anarchy” (Galaz et al., 2012, p. 22). Numerous independent centres of decision-making may self-organize and make mutual adjustments that order their relationships with one another (Ostrom, 1999b, 2010). This process may give rise to different forms and degrees of polycentric order, where stronger forms can be denoted as polycentric systems (Galaz et al., 2012). These systems are comparable in their structure and function to complex adaptive systems (Ostrom, 1999a), which have the capacity to adapt to external conditions by changing their rules as experience accumulates (Holland, 1995; Levin, 1998; Arthur, 1999; Miller and Page, 2007; Mitchell, 2009). Because of

the complexity-handling capacity of these systems, polycentricism has been considered as one appropriate model for international environmental law and governance (e.g., Folke et al., 2005; Ostrom, 2010).

However, empirical research on fragmentation and polycentricity at the international level has been hampered by inadequate methods and a lack of large datasets. For example, whereas these concepts are about macro-level architecture in a time-dependent sense, most previous studies have examined isolated cases of dyadic institutional interaction over a limited period of time (Zelli and van Asselt, 2013). We need to go beyond such reductionist methodologies and study the architecture, that is, the *system* of institutions at the macro-level (Biermann, 2007). Many important questions remain unexplored from a dynamic systems perspective.

Network theory has recently emerged as a widely applied tool kit for studying complex systems (Amaral and Ottino, 2004; Newman, 2011). The most important breakthrough in network science has been the discovery of striking regularities in the macro-structures of many complex systems that exist in the real world (Barabási and Albert, 1999; Watts and Strogatz, 1998; Ravasz et al., 2002). These common design principles provide a powerful justification for a network approach. By providing a common language and empirical methods, network theory has the potential to bring together fragmentation, polycentricity, and complexity studies, and provide some novel insights into the structure and dynamics of international environmental law and governance (e.g., Orsini et al., 2013).

3. A citation network perspective on international environmental treaty law

This study used cross-references as proxies for the evolving structure of international environmental treaty law, a strategy justified and explained below.

3.1. Cross-references as proxies for relationships among multilateral environmental agreements

To construct the complete network of multilateral environmental agreements, I needed to define objective criteria to connect them. In this study, I used “interrelated or cross-referenced provisions from one instrument to another” (Kiss and Shelton, 2007, p. 74) or simply citations or cross-references (these terms are used interchangeably in this paper) as proxies for an approximation of the relationships among multilateral environmental agreements. Most agreements contain references to a small number of pre-existing agreements by including their titles in the treaty texts, often in preambles, that the negotiating states consider as being highly relevant. This cross-referencing has been noted as a unique common characteristic of modern environmental treaties (Kiss and Shelton, 2007). Kiss and Shelton (2007, p. 87) observed that:

recent environmental agreements increasingly cross-reference other international instruments. Marine environmental treaties, for example, often cite to [the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978] or [the United Nations Convention on the Law of the Sea], including their rules by reference. The result could be to extend the legal effect of these instruments to states that have not ratified them but which ratify the texts that cite them, especially when the citation affirms the norms as customary international law.

States drafting and negotiating a multilateral environmental agreement would cross-reference other agreements for various reasons. The most frequently observed instances are when states

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