

How does homophily shape environmental collaboration networks among states? Evidence from the Asia-Pacific Economic Cooperation

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Abstract

Global environmental challenges demand cross-border collaboration. While international organizations play a pivotal role in facilitating such collaboration, the dynamics of collaboration networks among states remain underexplored. This study investigates the formation of environmental collaboration networks within the Asia-Pacific Economic Cooperation (APEC) from 2006 to 2021, employing a Temporal Exponential Random Graph Model (TERGM) to analyze the roles of actor-based and proximity-based homophily. Key findings reveal that network density increased over time, with China and the United States emerging as central contributors, while emerging economies like Vietnam and Thailand gained more prominence in recent years. Notably, collaboration extended beyond geographical proximity, highlighting the importance of trade linkages and institutional similarity in shaping partnerships. Contrary to expectations, actor-based homophily shows limited influence, whereas proximity-based factors (e.g. trade distance and institutional distance) significantly drive collaboration. These insights advance understanding of regional environmental governance and underscore the complex interplay of homophily in fostering international collaboration.

Keywords

Collaboration networks, Actor-based homophily, Proximity-based homophily, APEC

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Introduction

The greening of international society is well-documented by existing literature (Clapp & Dauvergne, 2011; Falkner & Buzan, 2019; Meyer et al., 1997). Due to the governing complexity (Fahey & Pralle, 2016) and large scale (Hird, 2008), environmental challenges cannot be tackled simply by individual countries but require a collective effort that transcends national boundaries. Therefore, the state needs to collaborate (Barrett, 2016; McCarthy, 2007) by establishing effective institutions for dealing with transnational problems (Deitelhoff & Müller, 2005; Grieco et al., 1993; Keohane, 1988; Oye, 1985). Regional environmental governance (REG) provides a starting point for complex environmental governance, and though taking shape in pluralistic forms, interstate REG remains the most typical out of all types of regional agreements (Balsiger & VanDeveer, 2018). However, existing literature still has an empirical gap, lacking a process-oriented perspective to explore the long-term dynamic mechanisms of collaboration networks

among different stakeholders. Regarding the literature on collaboration networks, scholars have explored the factors influencing network formation and the role of homophily within them (Isett et al., 2011; Provan & Kenis, 2008; Siciliano et al., 2021), whereas less attention has been paid to collaboration networks involving diverse state actors in the context of international organizations. Therefore, this study seeks to contribute both theoretically and empirically

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to the existing literature by unpacking the black box of long-term interactions among state actors, particularly focusing on the role of different types of homophily.

Who leads and who follows? How does homophily shape the formation of environmental collaboration networks among diverse states? Adopting an actor-based and process-oriented perspective to examine interstate environmental collaboration networks, this paper centers its research on the above two questions. The first question is fundamental in the sense that it presents basic features of the network including the proposing states and responding ones. The second question concerns mechanisms of network formation through testing both actor-based homophily (e.g. economic capacity, government attention to environmental governance, and public environmental concerns) and proximity-based homophily (e.g. trade volume, institutional distance, genetic distance, and spatial distance).

Employing a Temporal Exponential Random Graph Model (TERGM), this paper will examine the aforementioned research questions through the environmental collaboration networks in the Asia-Pacific Economic Cooperation (APEC). APEC is a regional economic forum established in 1989 to promote “balanced, inclusive, sustainable, innovative and secure growth and by accelerating regional economic integration” among its 21 members. While it was predominantly an economic forum, APEC member states have participated rather extensively in environmental cooperation projects, from 2006 to 2021, around 175 environmental cooperation project proposals were recorded on its database. APEC is selected for its diversity of member states, its state-centric environmental collaborations, as well as the relatively clear trade-offs involved in environmental collaboration under a trade organization.

In this article, we make three main contributions. First, this article focuses on the subject of international organizations. Existing research has emphasized much on the significance of international organizations in environmental governance (e.g. Barnett & Finnermore, 2005; Biermann & Pattberg, 2008; Siebenhüner, 2008). They provide a platform for countries to come together, share knowledge and resources, and coordinate their actions (Auer, 2000; Shaffer, 2001), which is not only conducive to resolving specific environmental problems but also helps enhance transparency and accountability in global environmental governance (Obydenkova, 2022). However, limitations exist at the same time, for it includes various bodies. The attempt to “lend more weight to national sovereignty to obtain better market conditions for ‘their’ resources (Görg & Brand, 2006, p. 114),” “unanimity associated with gridlock” (Blake & Payton, 2015, p. 383), decision-making conflicts (Sommerer et al., 2022), etc. complicate this matter, and similar issues are quite common (e.g. Gray, 2018; Kono, 2007). Therefore, in this paper, we discuss more about the actor interaction under the framework of the international organizations.

Second, this paper takes an interdisciplinary approach in its analysis. We find that existing literature, while offering a macro perspective to regime formation (including but not limited to the field of environmental governance), focuses less on the micro interactions among actors as noticed by scholars such as Pickering (2019). However, understanding both macro and micro-level interactions is equally important to grasp the dynamics of international environmental regimes (Young, 2010). There are some nascent attempts to do so, such as Perrin and Bernauer (2010) who draw on how the policy diffusion variable affects treaty ratification on transboundary air pollution agreements in Europe. Vandenbussche et al. (2025) examine the micro-level relational dynamics among stakeholders and their influence on issue frame convergence within collaborative governance. A more holistic review of the causal mechanisms must nonetheless be conducted. It is for this reason that the paper turns to the collaboration network formation to unpack the “black box” of interstate collaborative interactions.

Third, we expand the scope of actors participating in collaboration networks to a broader field. Earlier studies have extensively focused on cross-sector and interlocal collaborations such as the interaction mechanism (e.g. Cash et al., 2006), hierarchical interventions (Zhou & Dai, 2023a, 2023b), effectiveness (e.g. Liu & Tan, 2023; Shrestha, 2012; Ren et al., 2024) within one country (e.g. Behagel & Arts, 2014) or limited to basins (e.g. Lubell et al., 2020). It is undeniable that some environmentalists have considered the nation-state to be a “dysfunctional form of political organization” in tackling environmental problems (Falkner, 2013, p. 286). Nevertheless, it is still worthwhile to study the state (O’Toole, 1997) due to the critical role it plays in collaborative efforts (Dilulio & Kettl, 1995, p. 17).

Overall, this paper proceeds in four parts. First, we survey the relevant branches of literature to delineate existing insights for our research question. Second, we propose theoretical mechanisms for network formation and derive corresponding hypotheses. Third, we provide a detailed description of our data and analysis methods. Fourth, we present the results of our findings answering the aforementioned questions and pointing out the interaction mechanism and disparities among the APEC. Finally, we end with a brief conclusion and provide a policy implication for further research.

Literature review and hypotheses

Existing studies on regional environmental governance

The emergence of Regional Environmental Governance (REG) is often contrasted with the shortcomings of global environmental governance—“the rise of the region as the death of the global” as Conca (2012) puts it. The feasibility of global environmental governance is in question, from

high transaction costs of international regimes, weak compliance, and effectiveness to general fatigue toward the rhetoric of global conventions. Such developments contribute to the intensifying search for “alternative conceptual models and normative orders” (Balsiger & VanDeveer, 2012, p. 1).

Existing literature provides the theoretical foundations to understand what REG has to offer, which can be primarily viewed through two categories of ontological objectivity (natural region) and social ontology (imagined region). The former speaks to enhanced commonalities in specific natural environmental settings, for instance, the Alps (Balsiger & VanDeveer, 2012) or the Mekong River basin (Elliott, 2012), allowing for actors to tailor mitigating actions, hence increasing the efficacy of solutions. This line of argument highlights the importance of scale and collective action—that actors can self-organize, arguably more effectively, to govern the use of common property resources. The latter adopts a constructivist lens, bringing forth the idea that a “greater familiarity with key actors” can lead to better governance outcomes (Balsiger & VanDeveer, 2012, p. 4). Scholars offer several explanations to unpack this “familiarity”—ranging from political interests and agenda (Debarbieux, 2012; Gruby, 2017), norm diffusion (Conca, 2012; Elliott, 2012) to compatibility with regional economic communities (Chen, 2019; Davis, 2003; Esty, 1997).

Though more comprehensive in its theorizing, REG still has an empirical gap, lacking a process-oriented perspective to explore the long-term dynamic mechanisms of collaboration networks among different stakeholders. Furthermore, a systematic exploration of how homophily influences the formation of collaboration networks among states is also absent. In other words, it is necessary to examine the role and impact of homophily in network formation from various perspectives, such as the actor attributes, geographic factor, and sociocultural factors. Recognizing that APEC is a regional organization with its own distinct characteristics, this paper aims to contribute to the literature on regional environmental governance by examining the formation process of the APEC network through social network analysis and providing evidence from the Asia-Pacific region.

Existing studies on collaboration network

Collaboration network is regarded as a powerful approach to addressing environmental problems as it categorizes cross-boundary and cross-sector externalities (Bodin et al., 2020; Huang et al., 2017). Since the early 1990s, the study of policy networks has emerged as an important branch of research in political science, and as König and Bräuniger (1998) note, explaining the formation of policy networks is fundamental when understanding the relationship between policy networks and institutional setting of public decision-making. Since then, a myriad of studies has emerged exploring a range of theoretical mechanisms in network research pertaining to collaboration and tie formation. A

collaboration network could be viewed as systems that combine common public goods and service delivery with collective policymaking, grounded in principles such as trust, reciprocity, and mutual interdependence (Isett et al., 2011; Provan & Kenis, 2008). Collaboration networks are also characterized by their dynamic structures, which evolve over time to address changing stakeholder needs and environmental conditions (Kenis & Provan, 2009).

Numerous studies have investigated the influencing factors and internal mechanisms of collaboration network formation. Siciliano et al. (2021) present a useful summary of 15 mechanisms from 107 articles on network formation from 1998 to 2019. The mechanisms can generally be categorized into two distinct groups: exogenous and endogenous mechanisms. The former consists of general mechanisms that have been applied to non-network settings, while the latter concerns the self-organizing properties of the network, essentially network-specific “relational properties” that “influence the probability ties will be present or absent in the same network” (Contractor et al., 2006, p. 686). It is worth noting that homophily, the tendency of individuals or entities to connect with others who are similar to them, plays a significant role in the formation and dynamics of collaboration networks. Homophily is beneficial to communication and trust building among actors, as shared attributes—such as similar cultural backgrounds, values, or institutional norms—reduce the costs and uncertainties of collaboration (McPherson et al., 2001).

Existing studies on collaboration networks have explored the factors influencing network formation and the role of homophily within them. However, the focus has primarily been on collaboration among different sectors or local governments within the state, with limited research on collaboration networks involving diverse state actors in the context of international organizations. Therefore, this study seeks to contribute both theoretically and empirically to the existing literature by uncovering the formation process of collaboration networks among states, particularly the role of different types of homophily.

Hypotheses

Noting the contribution of existing literature, this paper adopts an actor-centric and a process-oriented approach to environmental collaboration network formation. It selects the network formation mechanisms using insights from regional environmental governance to derive homophily effects by testing both exogenous (actor-based) and endogenous (proximity-based) mechanisms within the network. Homophily is noted as one of the most important determinants of collaboration and network structure (McPherson et al., 2001). Countries with similar characteristics will be more likely to form network ties (Harrigan, 2017).

Actor-based homophily. Actor-based homophily refers to the tendency of states to associate with others that share similar

attributes, such as economic capacity, government attention to environmental governance, and public environmental concerns.

Economic capacity has been typically viewed as a combination of a country's financial resources, human capital, infrastructure, and institutional frameworks that together allow it to achieve economic objectives (Acemoglu et al., 2001). Its fundamental element is the state's ability to generate and manage financial resources, involving the capacity to collect taxes, mobilize capital, and effectively allocate public spending to stimulate economic activity (Weingast, 1995). The Environmental Kuznets Curve has hypothesized that environmental quality deteriorates steadily with economic growth till a turning point, usually before per capita income of \$8,000 (Grossman & Krueger, 1995). The implication of this is that countries with similar economic capabilities, and hence developmental stages, may face similar environmental concerns. In that sense, states with similar economic capacity would be more likely to have smoother coordination, better communication, and enhanced trust when resolving environmental problems.

H1: States collaborate more when they have similar economic capacities (in terms of GDP).

Attention resources are characterized by scarcity, flexibility, and transience (Bouquet et al., 2009). The allocation of attention plays a crucial role in government agenda-setting and policy implementation. Focused attention to environmental governance can mobilize support in terms of human, material, and financial resources. Moreover, leadership attention helps resolve potential conflicts during policy implementation. Generally speaking, when governments pay similar attention to environmental governance, they would share a mutual understanding of challenges and resources, making negotiation and collaboration more feasible.

H2: States collaborate more when they pay similar attention to environmental problems.

Apart from the two aforementioned bodies, the public, including individuals, communities, and civil society organizations, deserves equal attention in environmental collaboration, for governments often align their policies with the preferences of their populations (Burststein, 2003). As public trust in government is a crucial emotional component of political participation (AbouAssi & Wang, 2023; Wang & Zhang, 2024), it follows that when residents share similar environmental concerns, governments are more likely to implement policies that reflect these collective interests, as shared opinions facilitate smoother negotiations and agreements (Finnemore & Sikkink, 1998). It could also be regarded as a polycentric collaborative strategy, which fosters a centralized-brokered network structure with "multiple influence centers and high interconnectivity" (Huang et al., 2025, p. 1).

H3: States collaborate more when residents have similar environmental concerns.

Proximity-based homophily. Proximity-based homophily refers to the tendency of states to associate with others that share similar proximity in terms of trade distance, institutional distance, genetic distance, and spatial distance.

In the context of International Political Economy (IPE), the states' environmental collaboration is often shaped by the structural characteristics of their trade relationships. Interdependence emphasizes that as states become economically integrated, they would develop mutual dependencies (Keohane & Nye, 1973). However, these dependencies are more likely to lead to collaboration when the trade scale between states is similar, as it ensures that both parties have roughly equal stakes in maintaining the stability of the relationship. This creates a symmetry of interests, and subsequently, the likelihood of policy convergence increases without worrying about one country disproportionately benefiting from the collaboration (Baldwin, 1985).

H4: States collaborate more when they have closer trade relationships (in terms of bilateral trade volume).

The concept of institutional distance originated from the study of environmental differences in different countries. Initially, North (1990) pointed out that institutions include formal rules such as laws and regulations and informal rules such as culture and customs, and that the differences in these rules constitute the institutional distance between countries. Kostova (1999) refined this concept by categorizing it into regulatory distance, normative distance, and cognitive distance, which measure differences between countries in terms of legal policies, social norms, and cultural perceptions respectively. From the perspective of economics, greater institutional similarity could lower the costs with more easily formed compliance in collaborative projects (Williamson, 1975). From the perspective of public administration, alignment in economic, social, political, and ideological values allows for easier adaptation to form a "successful policy transfer" (Dolowitz & Marsh, 2000). Here, in this context, it refers to environmental "policy transfer." States with similar environmental regulations may find it easier to co-design environmental protection strategies.

H5: States collaborate more when they share closer institutional distance.

Along with institutional distance, genetic diffusion is more like a "soft" factor, referring to a "set of characteristics passed on across generations within a population over the very long run" (Spolaore & Wacziarg, 2009, p. 473). Genetic distance reflects more than biological traits; it also reflects

cultural ones such as implicit beliefs, customs, habits, biases, conventions, and more. People are more likely to trust and collaborate with those they perceive as similar, which can extend to interstate relationships. Genetic similarity may reinforce a sense of shared identity and common purpose (Tajfel & Turner, 1979).

H6: States collaborate more when they share closer genetic distance.

Spatial proximity is a related influencing variable that is utilized in many studies pertaining to intergovernmental collaborations. As Salazar and Claudel (2021) explain, the “tacit” nature of knowledge, which is best exchanged through face-to-face interaction between actors, and the increased exposure that comes with proximity forms the impact of geographical proximity on social ties. Balsiger and VanDeveer (2018, 2012) have argued extensively that the ecological spatial territoriality (such as river basins and mountain ranges) forms the inherent basis for cooperation. The influencing mechanism of ecological boundaries is straightforward—ecological boundaries give rise to cross-boundary problems, such as transboundary air or water pollution, that inevitably require interstate cooperation to be resolved:

H7: States cooperate more when they are physically proximate.

Environmental collaboration network among APEC economies

APEC is considered a regional organization with a loosely defined region. Existing studies on APEC, though rather scarce, suggest certain characteristics of APEC, which simultaneously disclose the reason why this organization is chosen as our study object. As a diverse organization, it includes economies from the global North and South, East and West, as well as regional blocs like ASEAN and East Asia (China, Japan, and Korea). It is the sole multilateral economic organization in the Asia-Pacific region that has integrated environmental issues into its core agenda. Its institutional design is informal and consensus-driven (Feinberg, 2008), with state leaders playing a central role in shaping the environmental agenda, making a state-centric analysis appropriate. Moreover, its environmental collaborative governance is embedded in its trade diplomacy and is in line with the framework of global environmental governance (Zarsky & Hunter, 1997, Asia-Pacific Economic Cooperation, 2014).

This research leverages the APEC project database for data collection. First, environment-related topics were identified from the APEC website, covering areas like agriculture, energy, food security, sustainable development,

and more. Second, official documents, including Leaders’ Declarations and Sectoral Ministerial Meeting records, were extracted for keywords such as “environment,” “sustainable,” and “green.” Third, projects matching these keywords were selected from the database and filtered for uniqueness.

Figure 1 shows the number of environmental projects undertaken by various APEC working groups from 2006 to 2021. As a whole, the number of environmental projects undertaken by various APEC working groups has increased in the 2010s, averaging 17.6 projects per year from 2006 to 2010, 31.2 projects per year from 2011 to 2015, and 29.2 projects per year from 2016 to 2020. This indicates that the environmental agenda has been rising in importance among APEC member states. The trend adheres to the greater trend of environmental consciousness in the world—“the global response to the triple planetary climate change crisis. . . pollution and waste intensified (United Nations Environment Programme, 2023).”

Who leads and who follows?

In this paper, a 19×19 directed matrix is constructed to represent environmental collaboration network among the 19 APEC economies. In these collaboration networks, nodes correspond to the APEC economies, while directed edges indicate collaborations, with the proposing economy acting as the sender and the cosponsoring economy acting as the receiver. By dividing the timeline into three periods: 2006 to 2010, 2011 to 2015, and 2016 to 2021, Figure 2 illustrates the dynamics of environmental collaboration networks among APEC economies between 2006 and 2021, suggesting two significant trends in terms of network formation.

First, the scope of economies initiating collaboration has expanded: while early proposals predominantly originated from the United States, Japan, Korea, and China, economies such as Vietnam and Thailand have progressively assumed more central roles in more recent networks. Overall, altogether 19 countries are included in this collaboration with China ranking as top one. China leads by a significant margin, proposing 126 projects, followed by the United States and Japan, which proposed 77 and 73 projects respectively, underscoring their leadership roles in shaping the APEC environmental agenda. This distribution highlights significant disparities in participation, with a small number of economies driving the majority of proposals. These economies are generally characterized by great economic capacity (e.g. China, the United States, and Japan are among the largest economies globally), well-established policy and institutional frameworks (e.g. China’s “Ecological Civilization” framework, and the U.S.’s long history of environmental legislation such as the Clean Air Act) and other strong points. Moreover, on average, there would be eight to nine countries taking the

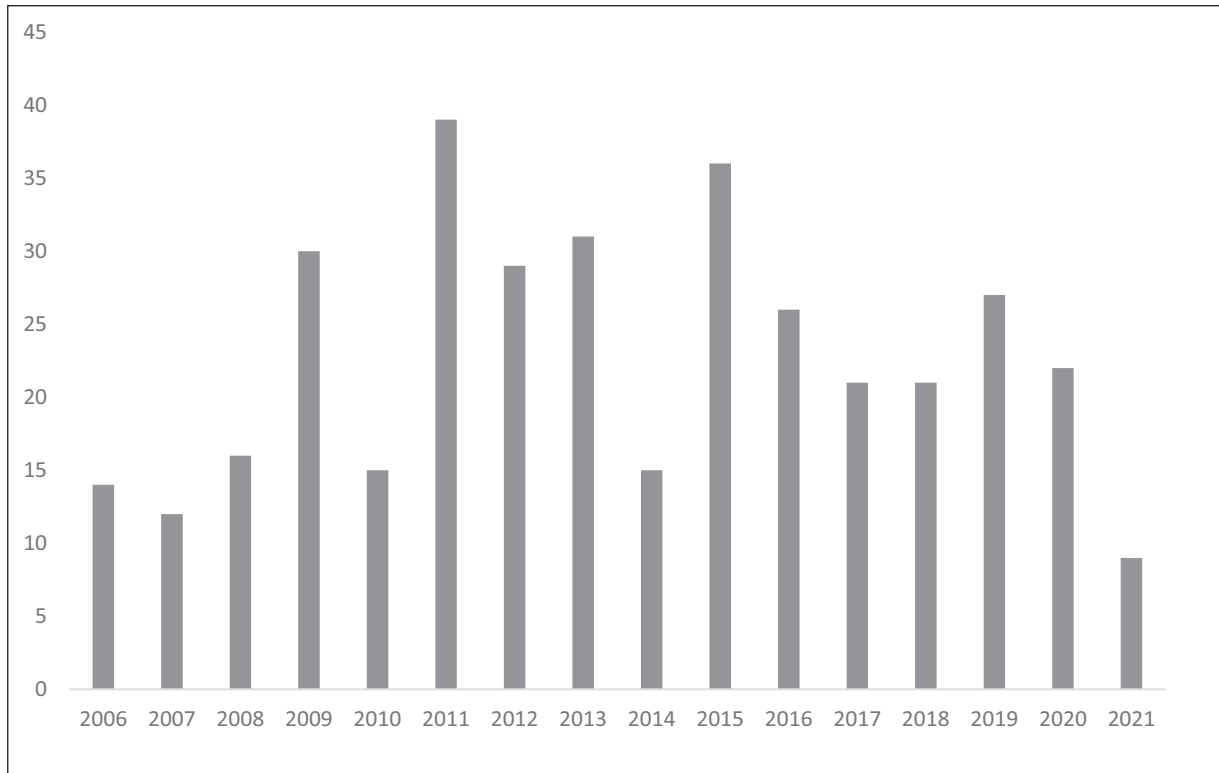


Figure 1. The number of environmental projects undertaken by various APEC working groups from 2006 to 2021.

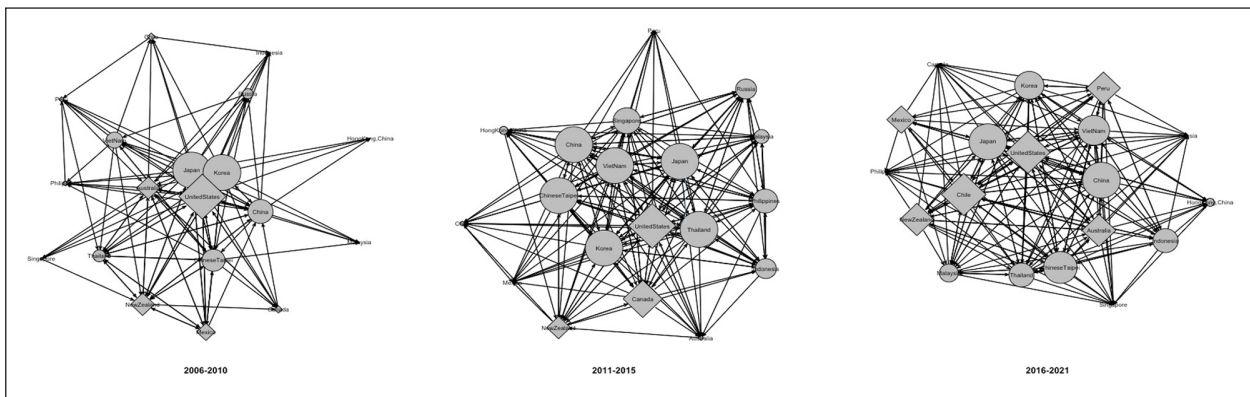


Figure 2. The dynamics of environmental collaboration networks among APEC economies between 2006 to 2021.
Note. In this figure, nodes represent APEC economies, with diamond nodes indicating economies located in Europe and the United States of America, and circle nodes representing economies in Afro-Asia. The size of each node reflects the number of environmental collaboration initiatives proposed by the respective economy during the specified time period. Directed edges between nodes denote environmental collaborations, where the outgoing arrow indicates the proposing economy, and the incoming arrow indicates the cosponsoring economy.

initiative to call for others to engage in environmental protection. From the initial seven countries (Korea, Japan, Mexico, Thailand, United States, China, and Vietnam) to an increasingly diverse body, the “green” idea managed to be passed to more nations through the APEC platform, and this group tended to be solid with no newcomers added in recent years.

Second, collaborative efforts have transcended geographical proximity, with an increasing number of intercontinental partnerships emerging over the study period. It is notable that the number and the size of diamond nodes

are increasing with denser network with circle nodes compared to the former two study periods, indicating a more balanced environmental collaboration among continents and a more diverse collaboration group.

Methodology

Model

In this paper, we employ a Temporal Exponential Random Graph Model (TERGM) to investigate the formation of

environmental collaboration networks among 19 APEC economies between 2006 and 2021. ERGM is widely utilized in social network analysis within the network governance literature for examining mechanisms of network formation. Compared with traditional logit regression models, ERGM offers the advantage of analyzing not only the influence of node attributes on network formation but also the interactions among network participants by incorporating structural factors (Gronow et al., 2020; J. Y. Kim et al., 2016). TERGM extends ERGM by addressing its limitation of static network analysis, thereby enabling a more comprehensive investigation of the generative mechanisms in dynamic, multi-period networks. The expression for the TERGM is given below:

$$P(Y^t = y^t | Y^{t-1} = y^{t-1}, \theta) = \exp\left(\sum_H \theta_H g(y^t, y^{t-1})\right) / c(\theta, y^{t-1})$$

where, y^t represents the environmental collaboration network at time t . H denotes the network attribute variables affecting network formation, including structural effects, node attributes, and homophily. θ_H is the coefficient of the above network attributes.

Variables

Homophily. Homophily serves as a core independent variable in this study, positing that actors with similar characteristics will be more likely to form network ties than actors with different characteristics. The concept of homophily is operationalized in this paper through two distinct approaches, that is actor-based homophily and proximity-based homophily.

First is actor-based homophily, which is quantified using the absolute differences between senders and receivers across three attributes: economic capacity, government attention to environmental governance, and public environmental concerns.

Economic capacity is measured by the GDP of each economy. This variable reflects the level of economic development. A higher GDP signifies a more developed economy with potentially greater influence on APEC issues. Data are sourced from the World Bank database.

Government attention to environmental governance is measured by the government expenditure on environmental protection as a share of GDP. The allocation of governmental expenditures represents the priority of the government's work, and the fact that the government spends more on environmental protection indicates that the government attention is placed more on environmental issues. The data source is the IMF database.

Public environmental concerns assess the extent to which the public in each APEC economy prioritizes

environmental protection over other major public issues, such as economic growth. Data are drawn from the World Values Survey (WVS): v104 from Wave 5 (2006–2010), v81 from Wave 6 (2011–2016), and q111 from Wave 7 (2016–2021). Higher values indicate a larger proportion of the public advocating for environmental protection over economic growth as a government priority.

Second is proximity-based homophily, which examines the influence of proximity in trade, institutions, genetics, and geography on the formation of network ties between economies.

Trade distance indicates trade links between senders and receivers, which is expressed as the reciprocal of export volumes from senders to receivers within a given time period. The data source is the WTO dataset.

Institutional distance indicates the similarity of political institutions between sender and receiver. This metric is calculated following the method outlined by Kogut and Singh (1988), using institutional indicators sourced from the ICRG database. Higher values signify greater institutional disparities.

Genetic distance reflects differences in the sociobiological and cultural characteristics of ethnic groups. Spolaore and Wacziarg (2009) suggested that genetic distance may be an important cause of differences in culture, communication styles, and learning abilities between ethnic groups. Data on genetics distance are from Spolaore and Wacziarg (2009).

Geographic distance is represented using an adjacency matrix, where the corresponding value in the distance matrix is 1 if two economies are adjacent and 0 for the rest.

Structural effects and node attributes. In addition to homophily, which is the main concern of this paper, network structure and actor attributes also significantly shape network formation. Therefore, we use the network structure and actor attributes as control variables.

First, network structure reflects the micro-mechanisms of network formation (Pallotti et al., 2013). In this paper, we focus on the impact of the following three network structures (see in Figure 3).

Reciprocity refers to a mutual relationship in which Economy A and Economy B cosponsor each other's proposals.

Multiple connectivity refers to a two-path connection, indicating a non-closed transitivity configuration within the environmental collaboration network. Specifically, after Economy B participates in a collaboration proposed by Economy A, Economy B subsequently proposes a collaboration that involves a third Economy C.

Transitive closure refers to the triple transitivity, suggesting multiple actors work together in a close cycle of collaboration. It occurs when Economy B participates in a collaboration proposed by Economy A, and Economy C participates in a collaboration proposed by Economy B,

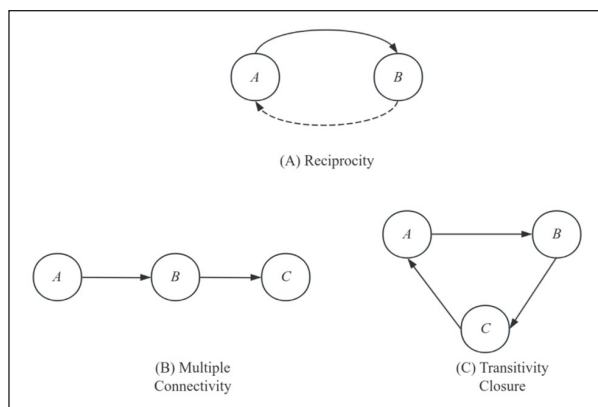


Figure 3. Network structures.

leading to the likelihood that Economy C will also participate in the collaboration proposed by Economy A.

Second, given that the collaboration network in this paper is directional, node attributes are categorized as sender attributes and receiver attributes. This distinction examines whether economies with specific attributes are more likely to propose environmental collaborations or cosponsor those initiated by other economies. The node attributes of environmental collaboration are analyzed from three dimensions: state capacity, government environmental attention, and public environmental concerns.

Results

The TERGM results are presented in Table 1, where the significantly negative coefficient for the edge term indicates that ties in the environmental collaboration network among APEC economies are unlikely to form at random.

Homophily is our main explanatory variable. First, we look into actor attribute-based homophily. The coefficients of economic capacity disparity and government environmental attention disparity are positive but not statistically significant at the 5% level, indicating that homophily in economic development or government attention to environmental protection does not significantly influence environmental collaboration among APEC economies. These results do not lend support to hypotheses H1 and H2. One possible explanation is the directional nature of environmental collaboration among APEC economies. From the perspective of institutional leadership, states with higher economic capacity and proactive environmental policies often act as leaders, creating frameworks and incentives for others to join collaborative efforts (Keohane & Victor, 2011; Young, 1991). It is more like a directional leader, as a good example or just “showing the way on how to deal with an issue” (Andresen & Agrawala, 2002, p. 2) proved by its own capacity, or it could be also understood as an instrumental leader who “seeks to find the means to achieve common goals and convince others about the (substantive) merits of a particular problem (refers to environmental issue in this context) or

Table 1. Regression results on environmental collaboration networks.

Variable	Model I
Edges	-3.8467 * (2.3188)
Actor-based homophily	
Economic capacity	0.1159 (0.0976)
Government attention to environmental governance	0.3067 (0.3159)
Public environmental concerns	0.0296 ** (0.0124)
Proximity-based homophily	
Trade distance	-8.0488 ** (3.3638)
Institutional distance	-0.2324 *** (0.0864)
Genetic distance	-0.0024 * (0.0014)
Geographic distance	-0.0334 (0.4266)
Sender attribute	
Economic capacity	0.4048*** (0.0912)
Government attention to environmental governance	0.4241* (0.2470)
Public environmental concerns	-0.0082 (0.0107)
Receiver attribute	
Economic capacity	0.0888 (0.1039)
Government attention to environmental governance	-0.035 (0.2634)
Public environmental concerns	-0.0144 (0.0105)
Network structure	
Reciprocity	-0.1521 (0.2610)
Multiple connectivity	0.0399 (0.0892)
Transitive closure	-0.0903 (0.1365)
Memory	0.1373 (0.0952)
Num. obs.	684
AIC	888.5963
BIC	983.0694
Log likelihood	-426.2982

solution framing” (Andresen & Agrawala, 2002, p. 2; Underdal, 1991, pp. 139–153). This result is validated in the control variables. The coefficients of economic capacity and government environmental attention in the sender attributes are significantly positive, indicating that the greater the economic capacity of the proposing economy and the more it invests in environmental protection, the more environmental collaborations it is likely to initiate. Moreover, counter to hypothesis H3, the coefficient of public environmental concerns disparity is significant and positive at the 5% level. This result suggests that economies with greater differences in public environmental concerns are more likely to form environmental collaborations.

In terms of proximity-based homophily, results prove that a shorter trade distance is important for the formation of environmental collaboration. With the decentralization of world trade, peripheral countries are getting closer to core countries (S. Kim & Shin, 2002), leading to a more visible overlap in trade and collaboration, particularly within the context of globalization (Cassi et al., 2012). This aligns with hypothesis H4. Institutional distance is our main explanatory variable. Empirical results demonstrate a

strong negative relationship between institutional distance and environmental collaboration. This is in line with the general theories: short institutional distance could enhance trade cooperation and reduce conflicts by forming good communication channels, reducing transaction costs, etc. (Cezar & Escobar, 2015; Chang et al., 2008). However, the risk is heightened in cases of significant institutional distance, where trust and enforcement mechanisms are less established (Globerman & Shapiro, 2003). Besides, genetic distance appears to exert a relatively weaker inhibiting effect on environmental collaboration, supporting hypothesis H6. A simile mentioned by Spolaore and Wacziarg (2013, p. 18) goes like this: “It is easier for someone to learn from a sibling than from a cousin, and easier to learn from a cousin than from a stranger.” As demonstrated by Guiso et al. (2009) regarding the barrier posed by greater genetic distance in trade formation, such distance may hinder the establishment of trust and increase coordination costs in collaborative endeavors. This is equally applicable to the environmental collaboration. Ethnic and cultural diversity could impede economic growth (Alesina et al., 1999; Easterly & Levine, 1997), or are not conducive to political stability (Fearon, 2003), which reduces the likelihood of collaboration formation. The coefficient of geographic distance, although negative, is not statistically significant, indicating that geographic distance is not a major constraint for APEC economies when considering environmental collaboration. This result is consistent with the results in Figure 2, where more and more cross-continental environmental collaboration has been achieved since 2006.

Finally, none of the coefficients of network structure are significant, indicating that interdependence does not significantly affect network formation after taking homophily into account. None of the estimated coefficients on the receiver’s actor attribute are significant, suggesting that collaboration on environmental protection is not limited to specific countries’ dyads. The estimated coefficient of memory is also not significant, indicating that collaboration in the previous period does not have a significant effect on collaboration in the current period.

In summary, proximity-based homophily is the primary factor influencing environmental collaborations among APEC economies. Specifically, both “hard” aspects, such as trade linkages, and “soft” aspects, such as institutional and genetic linkages, help lower transaction costs in the collaboration process. As a result, economies with higher exogenous homophily are more likely to engage in collaboration.

Conclusion

Over the 15 years of environmental collaboration within APEC, various factors have interwoven and exerted differing influences on the formation of collaboration networks.

This study empirically examines the specific network structure and the dynamics of network formation within APEC. Our findings indicate that from 2006 to 2021, network density increased, with China and the United States serving as notable contributors. Leadership within the network shifted over time, with emerging economies such as Vietnam and Thailand playing increasingly central roles. Collaboration initiatives have also transcended the limitations of geographical proximity. Furthermore, TERGM results reveal that factors such as trade linkages and institutional similarity significantly shape collaboration, while proximity in these endogenous variables has a relatively weaker effect.

We classify our key explanatory variables into actor-based and proximity-based homophily, with different attributes of homophily demonstrating varying degrees of influence. Actor-based homophily emphasizes shared attributes such as economic capacity, government attention to environmental governance, and public environmental concerns. This study found that public environmental concerns significantly foster collaboration, while no significant correlation was observed for state capacity or government attention. Proximity-based homophily, based on external similarities such as trade volume, institutional norms, and cultural affinity, exerted a stronger influence, albeit negatively impacting collaboration. Greater similarity in these aspects can reduce transaction costs, promote policy alignment, and so on. Overall, both forms of homophily play distinct roles, but proximity-based mechanisms are more decisive in shaping environmental networks.

There are several limitations to this study that should be noted. First, this study only covers data from APEC, which limits the validity and generalizability of our results. In future research, we plan to expand the sample size to include additional international organizations. Additionally, this study primarily focuses on analyzing the role of homophily factors, while other determinants, such as managerial and contextual factors, have not been considered. Therefore, an important direction for future research is to explore additional factors influencing inter-state collaboration networks. Despite these limitations, this study contributes theoretically to both regional environmental governance and collaboration network literature by adopting an interdisciplinary approach to uncover the formation process of collaboration networks among states through social network analysis.

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References

- AbouAssi, K., & Wang, R. (2023). Public participation at the local level in China: How does it work? A perspective from within. *Chinese Public Administration Review*, 14(2), 71–82.
- Acemoglu, D., Johnson, S., & Robinson, J. A. (2001). The colonial origins of comparative development: An empirical investigation. *American Economic Review*, 91(5), 1369–1401.
- Alesina, A., Baqir, R., & Easterly, W. (1999). Public goods and ethnic divisions. *The Quarterly Journal of Economics*, 114(4), 1243–1284.
- Andresen, S., & Agrawala, S. (2002). Leaders, pushers and laggards in the making of the climate regime. *Global Environmental Change*, 12(1), 41–51.
- Asia-Pacific Economic Cooperation. (2014). *2014 key APEC documents*. APEC Secretariat. <https://www.apec.org/docs/default-source/publications/2014/12/2014-key-apec-documents/key-apec-documents-2014v3.pdf>
- Auer, M. R. (2000). Who participates in global environmental governance? Partial answers from international relations theory. *Policy Sciences*, 33(2), 155–180.
- Baldwin, R. E. (1985). *The political economy of US import policy*. MIT Press.
- Balsiger, J., & VanDeveer, S. D. (2018). *Regional governance and environmental problems*. In N. Sandal (Ed.), *Oxford Research Encyclopedia of International Studies*. Oxford University Press. <https://doi.org/10.1093/acrefore/9780190846626.013.416>
- Balsiger, J., & VanDeveer, S. D. (2012). Navigating regional environmental governance. *Global Environmental Politics*, 12(3), 1–17.
- Barnett, M., & Finnemore, M. (2005). The power of liberal international organizations. *Power in Global Governance*, 161, 163–171.
- Barrett, S. (2016). Coordination vs. voluntarism and enforcement in sustaining international environmental cooperation. *Proceedings of the National Academy of Sciences USA*, 113(51), 14515–14522.
- Behagel, J. H., & Arts, B. A. S. (2014). Democratic governance and political rationalities in the implementation of the water framework directive in the Netherlands. *Public Administration*, 92(2), 291–306.
- Biermann, F., & Pattberg, P. (2008). Global environmental governance: Taking stock, moving forward. *Annual Review of Environment and Resources*, 33(1), 277–294.
- Blake, D. J., & Payton, A. L. (2015). Balancing design objectives: Analyzing new data on voting rules in intergovernmental organizations. *The Review of International Organizations*, 10, 377–402.
- Bodin, Ö., Mancilla García, M., & Robins, G. (2020). Reconciling conflict and cooperation in environmental governance: A social network perspective. *Annual Review of Environment and Resources*, 45(1), 471–495.
- Bouquet, C., Morrison, A., & Birkinshaw, J. (2009). International attention and multinational enterprise performance. *Journal of International Business Studies*, 40, 108–131.
- Burstein, P. (2003). The impact of public opinion on public policy: A review and an agenda. *Political Research Quarterly*, 56(1), 29–40.
- Cash, D. W., Adger, W. N., Berkes, F., Garden, P., Lebel, L., Olsson, P., Pritchard, L., & Young, O. (2006). Scale and cross-scale dynamics: Governance and information in a multilevel world. *Ecology and Society*, 11(2), Article 8. <https://www.ecologyandsociety.org/vol11/iss2/art8/>
- Cassi, L., Morrison, A., & Ter Wal, A. L. (2012). The evolution of trade and scientific collaboration networks in the global wine sector: A longitudinal study using network analysis. *Economic Geography*, 88(3), 311–334.
- Cezar, R., & Escobar, O. R. (2015). Institutional distance and foreign direct investment. *Review of World Economics*, 151, 713–733.
- Chang, K. I., Hayakawa, K., & Lee, H. H. (2008). The influence of cultural factors on trade in agricultural products. *Korea and the World Economy*, 9(2), 179–204.
- Chen, I. J. (2019). An analysis of establishing regional environmental governance through a mega regional trade agreement. *Vermont Journal of Environmental Law*, 20(1), 1–31.
- Clapp, J., & Dauvergne, P. (2011). *Paths to a green world: The political economy of the global environment*. MIT Press.
- Conca, K. (2012). The rise of the region in global environmental politics. *Global Environmental Politics*, 12(3), 127–133.
- Contractor, N. S., Wasserman, S., & Faust, K. (2006). Testing multitheoretical, multilevel hypotheses about organizational networks: An analytic framework and empirical example. *Academy of Management Review*, 31(3), 681–703.
- Davis, J. (2003). Regional economic integration, the environment and community: East Asia and APEC. *International Review of Applied Economics*, 17(1), 69–83.
- Debarbieux, B. (2012). How regional is regional environmental governance? *Global Environmental Politics*, 12(3), 119–126.
- Deitelhoff, N., & Müller, H. (2005). Theoretical paradise empirically lost? Arguing with Habermas. *Review of International Studies*, 31(1), 167–179.
- Dilulio, J. J., & Kettl, D. F. (1995). *Fine print: The contract with America, devolution, and the administrative realities of American federalism*. Center for Public Management, Brookings Institution.
- Dolowitz, D. P., & Marsh, D. (2000). Learning from abroad: The role of policy transfer in contemporary policy-making. *Governance*, 13(1), 5–23.
- Easterly, W., & Levine, R. (1997). Africa's growth tragedy: Policies and ethnic divisions. *The Quarterly Journal of Economics*, 112, 1203–1250.
- Elliott, J. (2012). *An introduction to sustainable development*. Routledge.
- Esty, B. C. (1997). Organizational form and risk taking in the savings and loan industry. *Journal of Financial Economics*, 44(1), 25–55.
- Fahey, B. K., & Pralle, S. B. (2016). Governing complexity: Recent developments in environmental politics and policy. *Policy Studies Journal*, 44(S1), S28–S49.

- Falkner, R. (Ed.). (2013). *The handbook of global climate and environment policy*. Wiley-Blackwell.
- Falkner, R., & Buzan, B. (2019). The emergence of environmental stewardship as a primary institution of global international society. *European Journal of International Relations*, 25(1), 131–155.
- Fearon, J. D. (2003). Ethnic and cultural diversity by country. *Journal of Economic Growth*, 8, 195–222.
- Feinberg, R. (2008). Voluntary multilateralism and institutional modification: The first two decades of Asia Pacific Economic Cooperation (APEC). *The Review of International Organizations*, 3, 239–258.
- Finnemore, M., & Sikkink, K. (1998). International norm dynamics and political change. *International Organization*, 52(4), 887–917.
- Globerman, S., & Shapiro, D. (2003). Governance infrastructure and US foreign direct investment. *Journal of International Business Studies*, 34, 19–39.
- Görg, C., & Brand, U. (2006). Contested regimes in the international political economy: Global regulation of genetic resources and the internationalization of the state. *Global Environmental Politics*, 6(4), 101–123.
- Gray, J. (2018). Life, death, or zombie? The vitality of international organizations. *International Studies Quarterly*, 62(1), 1–13.
- Grieco, J., Powell, R., & Snidal, D. (1993). The relative-gains problem for international cooperation. *American Political Science Review*, 87(3), 729–743.
- Gronow, A., Wagner, P., & Ylä-Anttila, T. (2020). Explaining collaboration in consensual and conflictual governance networks. *Public Administration*, 98(3), 730–745.
- Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The Quarterly Journal of Economics*, 110(2), 353–377.
- Gruby, R. L. (2017). Macropolitics of Micronesia: Toward a critical theory of regional environmental governance. *Global Environmental Politics*, 17(4), 9–27.
- Guiso, L., Sapienza, P., & Zingales, L. (2009). Cultural biases in economic exchange? *The Quarterly Journal of Economics*, 124(3), 1095–1131.
- Harrigan, P. (2017). The role of homophily in network formation: An analysis of similarity and network ties. *Journal of Network Theory*, 45(2), 152–167.
- Hird, J. (2008). The realities of environmental governance. *Public Administration Review*, 68(2), 395–398.
- Huang, C., Chen, T., Yi, H., Xu, X., Chen, S., & Chen, W. (2017). Collaborative environmental governance, inter-agency cooperation and local water sustainability in China. *Sustainability*, 9(12), 2305.
- Huang, C., Wang, Q., & Yi, H. (2025). Understanding collaborative water governance in local China: The role of collaborative strategy in shaping network structures. *Chinese Public Administration Review*. Advance online publication. <https://doi.org/10.1177/15396754251327845>
- Isett, K. R., Mergel, I. A., LeRoux, K., Mischen, P. A., & Rethemeyer, R. K. (2011). Networks in public administration scholarship: Understanding where we are and where we need to go. *Journal of Public Administration Research and Theory*, 21(suppl_1), i157–i173.
- Kenis, P., & Provan, K. G. (2009). Towards an exogenous theory of public network performance. *Public Administration*, 87(3), 440–456.
- Keohane, R. O. (1988). International institutions: Two approaches. *International Studies Quarterly*, 32(4), 379–396.
- Keohane, R. O., & Nye, J. S., Jr. (1973). Power and interdependence. *Survival*, 15(4), 158–165.
- Keohane, R. O., & Victor, D. G. (2011). The regime complex for climate change. *Perspectives on Politics*, 9(1), 7–23.
- Kim, J. Y., Howard, M., Cox Pahnke, E., & Boeker, W. (2016). Understanding network formation in strategy research: Exponential random graph models. *Strategic Management Journal*, 37(1), 22–44.
- Kim, S., & Shin, E. H. (2002). A longitudinal analysis of globalization and regionalization in international trade: A social network approach. *Social Forces*, 81(2), 445–468.
- Kogut, B., & Singh, H. (1988). The effect of national culture on the choice of entry mode. *Journal of International Business Studies*, 19, 411–432.
- Kono, D. Y. (2007). Making anarchy work: International legal institutions and trade cooperation. *The Journal of Politics*, 69(3), 746–759.
- Kostova, T., & Zaheer, S. (1999). Organizational legitimacy under conditions of complexity: The case of the multinational enterprise. *Academy of Management Review*, 24(1), 64–81.
- König, T., & Bräuninger, T. (1998). The formation of policy networks: Preferences, institutions and actors' choice of information and exchange relations. *Journal of Theoretical Politics*, 10(4), 445–471.
- Liu, Y., & Tan, C. (2023). The effectiveness of network administrative organizations in governing interjurisdictional natural resources. *Public Administration*, 101(3), 932–952.
- Lubell, M., Mewhirter, J., & Berardo, R. (2020). The origins of conflict in polycentric governance systems. *Public Administration Review*, 2, 222–233.
- McCarthy, J. (2007). States of nature: Theorizing the state in environmental governance. *Review of International Political Economy*, 14(1), 176–194.
- McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology*, 27(1), 415–444.
- Meyer, J. W., Frank, D. J., Hironaka, A., Schofer, E., & Tuma, N. B. (1997). The structuring of a world environmental regime, 1870–1990. *International Organization*, 51(4), 623–651.
- North, D. C. (1990). *Institutions, institutional change and economic performance (Vol. 332)*. Cambridge University Press.
- Obydenkova, A. (2022). Global environmental politics and international organizations: The Eurasian and European experience. *Post-Communist Economies*, 34(5), 565–576.
- O'Toole, L. J., Jr. (1997). Treating networks seriously: Practical and research-based agendas in public administration. *Public Administration Review*, 57, 45–52.
- Oye, K. A. (1985). Explaining cooperation under anarchy: Hypotheses and strategies. *World Politics*, 38(1), 1–24.
- Pallotti, F., Lomi, A., & Mascia, D. (2013). From network ties to network structures: Exponential Random Graph Models

- of interorganizational relations. *Quality & Quantity*, 47, 1665–1685.
- Perrin, S., & Bernauer, T. (2010). International regime formation revisited: Explaining ratification behaviour with respect to long-range transboundary air pollution agreements in Europe. *European Union Politics*, 11(3), 405–426.
- Pickering, J. (2019). Deliberative ecologies: Complexity and social-ecological dynamics in international environmental negotiations. *Global Environmental Politics*, 19(2), 61–80.
- Provan, K. G., & Kenis, P. (2008). Modes of network governance: Structure, management, and effectiveness. *Journal of Public Administration Research and Theory*, 18(2), 229–252.
- Ren, H., Zhou, L., & Gao, Y. (2024). Policy tourism and economic collaboration among local governments: A nonparametric matching model. *Public Performance & Management Review*, 47(2), 476–504.
- Salazar Miranda, A., & Claudel, M. (2021). Spatial proximity matters: A study on collaboration. *PLoS ONE*, 16(12), e0259965.
- Shaffer, G. C. (2001). The world trade organization under challenge: Democracy and the law and politics of the WTO's treatment of trade and environment matters. *Harvard Environmental Law Review*, 25, 1.
- Shrestha, M. K. (2012). Self-organizing network capital and the success of collaborative public programs. *Journal of Public Administration Research and Theory*, 23(2), 307–329.
- Siciliano, M. D., Wang, W., & Medina, A. (2021). Mechanisms of network formation in the public sector: A systematic review of the literature. *Perspectives on Public Management and Governance*, 4(1), 63–81.
- Siebenhüner, B. (2008). Learning in international organizations in global environmental governance. *Global Environmental Politics*, 8(4), 92–116.
- Sommerer, T., Squatrito, T., Tallberg, J., & Lundgren, M. (2022). Decision-making in international organizations: Institutional design and performance. *The Review of International Organizations*, 17, 815–845.
- Spolaore, E., & Wacziarg, R. (2009). The diffusion of development. *The Quarterly Journal of Economics*, 124(2), 469–529.
- Spolaore, E., & Wacziarg, R. (2013). How deep are the roots of economic development? *Journal of Economic Literature*, 51(2), 325–369.
- Tajfel, H., & Turner, J. C. (1979). An integrative theory of intergroup conflict. In W. G. Austin & S. Worchel (Eds.), *The social psychology of intergroup relations* (pp. 33–37). Brooks/Cole.
- Underdal, A. (1991). *Solving collective problems: Notes on three modes of leadership*. The Fridtjof Nansen Institute.
- United Nations Environment Programme. (2023). *UNEP Annual report 2023*. Retrieved December 29, 2024, from <https://www.unep.org/resources/annual-report-2023>.
- Vandenbussche, L., Edelenbos, J., & Eshuis, J. (2025). Collaboration in action: How micro-level relational dynamics are connected with issue frame convergence in collaborative governance networks. *Public Management Review*, 27, 1116–1134.
- Wang, C., & Zhang, X. (2024). Governance capacity, social justice, social security, and institutionalized political participation in China: A moderated mediation model. *Chinese Public Administration Review*, 15(3), 194–206.
- Weingast, B. R. (1995). The economic role of political institutions: Market-preserving federalism and economic development. *The Journal of Law, Economics, and Organization*, 11(1), 1–31.
- Williamson, O. E. (1975). *Markets and hierarchies: Analysis and antitrust implications: A study in the economics of internal organization*. University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship.
- Young, O. R. (1991). Political leadership and regime formation: On the development of institutions in international society. *International Organization*, 45(3), 281–308.
- Young, O. R. (2010). *Institutional dynamics: Emergent patterns in international environmental governance*. MIT Press.
- Zarsky, L., & Hunter, J. (1997). Environmental cooperation at APEC: The first five years. *The Journal of Environment & Development*, 6(3), 222–251.
- Zhou, L., & Dai, Y. (2023a). Within the shadow of hierarchy: The role of hierarchical interventions in environmental collaborative governance. *Governance*, 36(1), 187–208.
- Zhou, L., & Dai, Y. (2023b). What is the role of hierarchical interventions? Insights from the evolution of water collaborative Governance in China. *Environmental management*, 71(3), 641–654.