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The Relationship Between Information-Sharing and Resource-Sharing Networks in Environmental Policy Governance: Focusing on Germany and Japan

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Environmental issues are among the most critical issues nowadays. These issues are no longer confined to individual countries, and international society has been progressing in building global dialogues since the early 1970s. Within these international efforts, Germany and Japan have played essential roles in global environmental governance. However, there are major differences in nation-level environmental policies in both countries.
Governance based on network structure is more efficient than that based on hierarchy for solving complex problems. The network structure is formed through horizontal cooperation among various autonomous actors, and the relationship intensity among actors is one of the key concepts in the governance. Using social network analysis as a framework to explain complicated societal structures explains how interaction among actors creates networks, and these networks further affect their interactions.
The purpose of this study is to investigate the structure of environmental policy governance as collaborative governance in Germany and Japan. To address this goal, this paper analyzes the relationship between the informational dimension of governance networks and its complement resource-sharing networks in both countries. The results show that the information-sharing networks have lower-level network influence on the resource-sharing networks as higher-level networks even if not all of the information factors have singular influences. The results suggest that the information-sharing networks may be one of the pieces of the puzzle for explaining this phenomenon in environmental governance in Germany and Japan.

Keywords: Collaboration governance, Environmental policy governance, Germany, G- GEPON 2, Homophily, Japan, J-GEPON 2, Network governance, Social network analysis, Quadratic assignment procedure

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Introduction

Environmental issues caused by climate change due to global warming involving issues such as ecosystem destruction or natural disaster are no longer limited to the strict category of "environment studies," but have an immediate impact throughout society including politics, economy, and national security.

Furthermore, environmental issues caused by climate change are not limited to geographical boundaries. They affect not only neighboring countries, but also those on the opposite sides of the earth. The Special Report on Emissions Scenarios (SRES) projected six scenarios, including "sea levels will continue to rise in the 21st century because of thermal expansion and loss of land ice" (Intergovernmental Panel on Climate Change (IPCC), 2007), with the crucial cause of greenhouse gas emission during the 21st century contributing to such rises.

However, the problems inherent within environmental issues have characteristics which cover a wide range of causes and have impact without specific targets. In addition, such problems are said to be cumulative over a long period (Meadowcroft, 2009; Urban, 2015). For example, with regards to climate change issues, the participation of various public actors is important because all actors may suffer simultaneously the consequences of greenhouse gas emissions and related effects caused by the emissions. Pinpointing the causes of environmental problems is rarely simple and, similarly, solving the problems is not an easy task, particularly that of identifying who has responsibility for such issues. These complex characteristics of environmental issues give rise to major differences among stakeholders during the policy making process, and this raises the risk of social conflict. For this reason, in order to confront environmental issues, governance which is capable of anticipating antagonism and conflicts and establishing policies by collaboration and coordination in society is indispensable (O'Riordan & Jäger, 1996).

Based on a growing awareness of the characteristics of environmental issues, many countries have composite governance systems with participating various actors for protecting the environment, providing public environmental services, and making policies that address these problems (Kim & Song, 2015; Wurzel, 2006). Navigating different structures of environmental governance within the context of each country is challenging and, on the global level, international society has been progressing in building such global governance systems for responding to global environmental issues.

Within these efforts, Germany and Japan have played essential roles in relations with other countries as countries with responsibility for greenhouse gas emissions (United Nations, 2018). These two countries are steadily making progress in the field of renewable energy. However, there are major differences in country-level environmental policies in Germany and Japan. Germany can be considered a forerunner country in initiating and legislating environmental policies. Germany

was portrayed as an of environmental leader country from 1970s in Europe. Such environmental policies towards Energiewende (energy transition) started to change in the late 1980s through focus on renewable energies and a gradual phasing-out of nuclear power. The German government also did not abandon their pro-environmental stance during the decades of post-unification, even sometimes they had to concede they lost their status as an environmental forerunner of EU because of economic challenges since post-unification (Foljanty Jost & Jacob, 2004; Wurzel, 2006). In contrast, in the case of Japan, the country has been reluctant to promote renewable energy. The composition of power sources in Japan has been mainly fossil-fuel energy sources and nuclear energy. Until the Fukushima Daiichi nuclear disaster in March 2011, Japan was primarily dependent on nuclear power generation to reduce greenhouse gas emissions. After the nuclear disaster, the Japanese government shifted dramatically by forcing a shut-down of all nuclear power plants and planning to phase out nuclear power, and still almost nuclear power plants have stopped operations, even though some plants are preparing to restart (Nariyama, 2015).

In this context, understanding the relational structure of collaborative governance in Germany and Japan is meaningful by unpacking the relationships between factors in network and network structure from the collaborative governance perspective that such collaboration and networks form a continuum. Therefore, the purpose of this study is to examine the relationships between information factors including network and resource sharing networks as aspects of lower and upper levels in the collaborative continuum of energy policy actors in Germany and Japan using the two datasets of the Global Environmental Policy Network (GEPON) surveys (detailed in the Methodology section of this paper).

This paper is organized as follows. First, we review the literature explaining collaborative networks, network governance, and the theory of homophily in the next section. In the third section, we set the research questions and hypotheses based on the preceding theoretical background. Section four outlines our methodology and data setting in more detail. To answer the research questions, we apply the Quadratic Assignment Procedure (QAP) that has been used rarely in the context of environmental policy governance. We used UCINET 6.665 (Borgatti, 2002) to analyze the data, which was used to calculate the logistic regression of quadratic assignment procedures. Finally, in the last two sections, we present the results of our analysis summarize the empirical findings, and discuss future directions and limitation for this research.

Theoretical Background

Network governance, collaborative governance, and homophily are three theoretical concepts that have been used to explain the relationship among actors, the activities in which they collaborate, and the similarities in their overall structures, respectively.

Network governance

Networked governance occurs when governmental actors team up with non-governmental actors to address challenges and issues. Networked governance usually occurs when issue areas involve multiple actors, broad (wide) issues, complex issues, and issues that may take a long time to resolve. During the last few decades of the 20th century, government actors at all levels have seen growing complexity in public administration issues that have involved an ever-increasing range of actors. The actor range spans individuals to firms to government administration, including varying levels such as local, regional, national, and supra-national. The actor range – and the network of relationships in which they function – has expanded in concert with the increasing complexity in resolving current social and public issues. From a political perspective, Sørensen and Torfing (2005, pp. 197–198) suggest a linkage between the concept of network governance with "post-liberal" democratic theories and its possibilities for ushering in "new forms of interactive network governance."

The theory of "network governance" is relatively new, being identified by Jones, Hesterly, & Borgatti as "autonomous firms…engaged in creating products or services based on implicit and open-ended contracts" (Jones, Hesterly, & Borgatti, 1997, p. 914). In addition to creating a working definition of network governance, their description of the literature concerning network governance illustrates the key common points of collections of actors (may be firms or individuals) having some kind of interdependent relationship arrangements, and that such relationships may form a pattern (Jones et al., 1997, p. 915). In contrast to defining the term broadly, Lewis (2011, p. 1221) takes a different approach by dividing the literature into two generations: the first examining the initialization or formation of network governance, and the second going further to investigate the implications and democratic possibilities of such governance.

Problem-solving approaches using the concept of networked governance suggest that by working together, government and non-governmental actors may be able to create innovative policies for dealing with pressing and complex issues. For example, studies in networked governance approaches to environmental issues have focused on municipal governments (Betsill & Bulkeley, 2004). However, such approaches are not without their limitations. Such limitations include incorporating the networked governance approaches into existing governance structures and, as Mathur & Skelcher (2007, p. 228) point out, the "lack of political oversight, limited democratic competence of new organizational form, and informality of operations" may be hindrances. In

addition, issues involving the structure of such exchanges remain challenging in terms of adaptation, coordination, and "safeguarding exchanges" (Jones et al., 1997, p. 925).

Such approaches have focused on applying the concept of networked governance to existing institutional structures, with a focus on how such structures are incorporating and undertaking such governance models. However, few studies have adopted the opposite approach of applying network theory to governance. Provan & Kenis (2008, p. 229) suggest that "understanding the functioning of networks is important…[to] understand why networks produce certain outcomes…" This transitive approach suggests that there may be some merit in looking at network governance from new theoretical and methodological perspectives.

Collaborative governance

Collaborative governance, as a sub-approach related to network governance, is an additional theoretical stream used to explain information- and resource-sharing relationships. To date, some approaches have defined collaborative governance from the perspective of actor activities. From an adaptive perspective, McDougall, Jiggins, Pandit, Thapa Magar Rana, & Leeuwis, 2013 (p. 1236) define collaborative governance as "an approach to the governance of socio-ecological systems in which groups of actors purposefully base their decision-making on social learning and critical reflection; emphasize inclusion and equity; and strive for balanced and strategic collaboration with other actors." Other definitions focus on the practice of collective decision-making as a key point. To this end, Ansell & Gash (2008) define collaborative governance as "a governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative…" (Ansell & Gash, 2008, p. 544).

Studies in the collaborative governance model have not been restricted to state or public actors, but also have focused on collaborative activities in business and the private sector. For example, in terms of business (for-profit) models, incentives including "cost reductions, productivity improvements, and product/market strategy" have been identified among information and resource-sharing practices in the same industry (Barrett & Konsynski, 1982). Information sharing and collaborative efforts have been studied via the social exchange model as well in terms of inter-organizational resource sharing (Wu, Chuang, & Hsu, 2014). Resource and information sharing as part of collaborative interaction and governance between citizens and government shows that a combination of actors (citizen-state) addressing complex issues (i.e., the environment) may yield new theoretical and methodological models (Brink & Wamsler, 2018).

Collaborative governance involving actor groups and their activities tends to emphasize the relationships among the actors, the means by which they communicate and exchange information, the "intensity" of their relationships, and similarity. Corbett & Noyes (2008) suggest that the last two factors – namely, "relationship intensity" and "institutional similarity" – are key dimensions in assessing the possibilities of collaborative governance (Corbett & Noyes, 2008). In their study,

they define relationship intensity as "the intensity of the interaction…sought between participating programs and agencies" (Corbett & Noyes, 2008, p. 4). They suggest that such intensity can be measured by multiple types of interaction such as communication, cooperation, coordination, collaboration, convergence, and consolidation (Corbett & Noyes, 2008, p. 4). They use four case studies of institutional similarity across four U.S. states in terms of routinized, mixed, and nonroutinized – defined as core tasks, mixed tasks, and tasks that "[rely] on professional norms," respectively – to show how public services institutions can take on or assume similarities in structure depending on their activities and service focus (Corbett & Noyes, 2008, p. 5). An additional promising approach has been the consideration of organization structure, in terms of defining leadership and responsibility centers, and Valero (2015) points out such challenges in reference to Japan and Korea.

In essence, collaborative governance involves certain dynamics including actor relationships, duration, and similarities among actor types. Furthermore, there is a decided emphasis on collaboration in certain similar policy areas wherein actors are established, pursue good relationships, and are in appropriate positions to share information resources and communication. However, to date, there has been little research that focuses specifically on measuring similarities among actors in predetermined areas.

Theory of Homophily

The third theoretical stream pertinent to this paper is the concept of homophily. Mcpherson, Smith-lovin, & Cook (2001, p. 416) define homophily as "the principle that… contact between similar people occurs at a higher rate than among dissimilar people" and note the localization nature of the concept. Currarini, Matheson, & Vega-Redondo (2016, p. 2) define homophily as "[contact that] tends to be more frequent among similar agents than among dissimilar ones" and focus mainly on the size of groups as an important characteristic of homophily. Homophily as a principle has also been used to explain how new ties are formed (through contact with those possessing similar characteristics) but also as a factor that shows "preference for similar others" (Kossinets & Duncun, 2009, p. 405).

In this research, we argue that homophily may be present and influence the relationship among actors conducting activities in a country-based environmental policy network. To that end, we believe that our comparison of German and Japanese actors in their respective national milieux warrants investigation and share similar characteristics. Both sets of actors chosen for the J-GEPON 2 and G-GEPON 2 surveys are undertaking activities within their respective countries, share language and cultural characteristics in such national milieu, and have been conducting operations long enough to enable them to form relationships with other similar organizations as well as state institutions and the public.

Research Questions and Hypotheses

The definition of collaboration varies according to researchers, and many studies have taken the approach that collaborative relationships are not fixed, but are part of a continuum based on escalation of relationship intensity and level of activities (Kanter, 1994; Kearns & Forrest, 2000; Wanna, 2008). In this perspective of collaborative governance, information exchange and sharing are involved in relatively low-level collaboration, then, as the intensity of relationship and level of trust grow, the level of collaboration becomes higher to enact resource exchange and sharing (Ansell & Gash, 2008; Wanna, 2008) The collaborative network is one of the key concepts of collaborative governance as a combination of two complementary concepts: collaboration and networks. It implies that network structure is an incubator of collaboration because organizations can be provided with opportunities for of new information, new resources, and social capital, and such combinations intensify collaboration. On the other hand, collaboration makes networks dense and substantial and, through successful collaboration, builds trust, deepens existing relationships, and facilitates new relations.

From these theoretical assumptions, this paper aims to analyze empirically information factors and resource sharing in policy governance networks. The paper, hence, particularly tries to answer two main questions as follow:

> RQ1) Do similarity factors in the informational dimension in governance influence resource-sharing networks in Germany and Japan?
>
> RQ2) Does the information sharing network in governance influence the resource -haring network in Germany and Japan?

To answer the research questions, we derive three hypotheses:

> H1) Similarity in information type that two organizations consider important in the information-sharing network increases connectivity in resource-sharing relations.
>
> H2) Similarity in organization type that two organization consider important as information sources in the information-sharing network increases connectivity in resource-sharing relations.
>
> H3) Connectivity in the information-sharing network increases connectivity in the resource-sharing network.

The above two hypotheses are set for testing RQ1 that homophily influences information factors, and H3 is set for examining RQ2 that the causal relationship between sharing information and sharing resources on the collaborative continuum in collaborative governance. In examining the hypotheses, this paper uses social network analysis as a proposed means to understand these

relationships. Also, in order to go beyond merely describing the networks and to grasp the underlying social structure, quadratic assignment procedure (QAP) is applied in the analysis.

Methodology and Data

Social Network Analysis

Social network analysis is used to explore the meaning of the structure made up by social relations focusing on the interaction among entities and revealing its concrete substance. The most basic component of a network is a *node* representing each entity, which can be almost anything, and *ties* that interlink through nodes. A connected chain of nodes can be located on opposite ends of a network yet be connected to each other indirectly. In this manner, various nodes within a system may affect each other (Borgatti, Everett, & Johnson, 2018). The purpose of social network analysis is to find and interpret the characteristics in the network, and social network analysis emphasizes the position in which a node embedded and the attributes in the network, rather than an individual node's attributes (Butts, 2008; Newman, 2006). Thus, this techniques can analyze social roles and influences using various forms of relationships that appear on the society.

These characteristics are mainly analyzed by relationship data that represents exchange and flow of information or materials. Accordingly, the data for social network analysis is different from data for traditional statistics. Rather than a random sample, the network data is basically relational data, so there is a dependency between observations. It is difficult to apply OLS (ordinary least squares) in the regression to network data because this method assumes that the observations are independent and identically distributed. Thus, a bootstrap method is used to calculate the test statistics. This method tests for significance and assumes that the density of network is 0 in the population and aims to find the contingency of the created density. Based on this, various inference statistical methods can be used, and it may be used to provide an understanding of relationships among networks (Lee, Lee, & Sohn, 2016).

Quadratic Assignment Procedure (QAP)

Quadratic assignment procedure (QAP) is a nonparametric, permutation-based test that preserves the integrity of observed structures. The QAP has been developed to explain complex network dependencies based on the principle of the bootstrapping procedure (Broekel, Balland, Burger, & van Oort, 2014; Krackhardt, 1987). In the QAP, rows and columns of the independent matrix or matrices and the dependent matrix are repeatedly permutated to recompute the regression to obtain random statistical results, and correlations are obtained between the independent matrix or matrices and the dependent matrix. Through this process, a test statistic to test the hypothesis is derived. Significance is tested by comparing the actual estimates to the distribution of permuted networks.

QAP requires the same set of nodes and it can be conducted to the matrices which, in turn, can be composited to one-mode matrices that are not affected by the type of data (Chen, Ilany, White, Sanderson, & Lanzas, 2015; Park & Thelwall, 2008; Wasserman & Faust, 1994). The significance is stabilized as the number of permutations increase. We set the number of permutations to be 100,000. It means this step was repeated 100,000 times in order to estimate standard errors for the statistics of interest (Borgatti et al., 2018; Dekker, Krackhardt, & Snijders, 2007; Holvoet, Dewachter, & Molenaers, 2016; Lee et al., 2016; van Duijn & Huisman, 2011). The multiple regression-quadratic assignment procedure (MR-QAP), a multiple regression analysis used to measure cause and effect on the independent variable matrices for dependent variables expressed as network matrix, was then applied (Borgatti et al., 2018; Broekel et al., 2014; Holvoet et al., 2016; Maciel, 2018). Logistic regression-quadratic assignment procedure (LR-QAP), a logistic regression model used for network data, was then applied. LR-QAP is an extension of the QAP-based MR-QAP and was originally designed for binary data. Despite binary dependent variables, compared to MR-QAP, LR-QAP is not frequently used in empirical social network analyses and the interpretation of the coefficients is not based on odds as in MR-QAP. Borgatti et al. (2018) note the necessity of running LR-QAP and indicate that p-values generated for binary dependent variables through MR-QAP are valid and interpretable (Borgatti et al., 2018). This paper applies LR-QAP, which is consider as practical technique for analyzing dyadic level, to analyze effects of information aspect into resource sharing network, but also adds a part of results and findings from the MR-QAP as the appendix for checking the robustness of the findings using both procedures. Multiple regression QAP (MR-QAP) is more frequently used, and the p-value of MR-QAP on binary data is interpretable, but difficulties arise when the interpreted coefficients are not based on odds, so it is necessary to run the LR-QAP procedure (Borgatti et al., 2018; Holvoet et al., 2016).

The GEPON Surveys as Datasets

The GEPON surveys are devised for cross-national comparative study of environmental policy-making governance. The target organizations are selected by criteria for identifying important actors in the environmental governance such as participation in policy-making process or global regimes, work on reducing greenhouse gas emissions, and involvement in policy. The questions were created to inquire about four elements of environmental policy-making governance such as the structure of information and resource sharing networks, attitude to policies, and organizational demographics. The J-GEPON 2 survey was undertaken from December 2012 to June 2013 in Japan, and the G-GEPON 2 survey was administered between November 2016 and February 2017 in Germany. The response rate for Japan was 62.2 percent (107 out of 172 target organizations), and the response rate for Germany was 38.8 percent (69 out of 183 target organizations).

In this paper, we used two datasets for comparison. Both surveys are part of the GEPON survey series and ask similar questions (in Japanese and German, depending on the target country) concerning information importance and information resources among environmental policy-

making actors. Both surveys also asked respondents to indicate with whom such information and resources are exchanged and shared.

Data Setting

We used six questions to generate thirteen relational matrices each country from G-GEPON 2 and J-GEPON 2: Four matrices from factor (1), which is the similarity of the information type that the organization considers important; four matrices from factor (2) as the similarity in organization type that the organization considers to be an important information source; four matrices from the information-sharing network; and one resource- sharing network as a dependent variable. The matrices of factor (1) and factor (2) are based on four information types. The matrices based on the information sharing network as factor (3) consist of the information-sharing network and the network structural effects, i.e., reciprocity, transitivity, and preference attachment. Tables 1 and 2 give an overview of the questions that were used to inquire about the factors in the informational dimension that were considered to have a possible influence on resource-sharing networks.

Table 1. Factors and Questions (Translated into English)

Factors	Questions
(1) Similarity of information importance	Q3. How important is the following information about global warming/climate change for your organization? Please rank each information item using a scale from 1 (not important) to 5 (very important).
	A. Information about international activities
	B. Information about domestic activities
	C. Information about science and technology
	D. Information about the impact of global warming/climate change on society and the economy
(2) Similarity of information resource	Q4. For each type of information given below, please choose those organizations that are an important source of information for your organization.
	A. Information about international activities
	B. Information about domestic activities
	C. Information about science and technology
	D. Information about the impact of global warming/climate change on society and the economy
	Types of organization: 1) Ministry of the Environment, 2) Ministry of Economy, 3) Local governments, 4) Political Parties, 5) Academic Institutions, 6) Think Tanks, 7) Environmental Consultants, 8) Environmental NGOs, 9) United Nations Organizations, 10) Other International Organizations, 11) Members of your Organization, 12) Other
(3) Information-sharing network	Q7. Please indicate all the organizations, to which your organization provides information (including advice, joint workshops, etc.).
	Q8. Please indicate all the organizations from which your organization receives information (including advice, joint workshops, etc.).

Source: J-GEPON 2 (2012-13) and G-GEPON 2 (2016-17) Surveys

Table 2. Dependent variables and questions (Translated into English)

Dependent variable	Questions
Resource sharing Network	Q9. Please indicate all the organizations to which your organization gives practical or human resource support (except informational support).
	Q10. Please check all the organizations from which your organization receives practical or human resource support (except informational support).

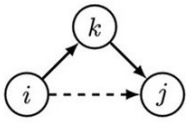
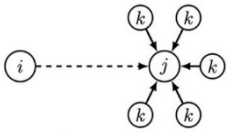
Source: J-GEPON 2 (2012-13) and G-GEPON 2 (2016-17) Surveys

The raw data required certain processing steps. First, in order to synchronize the categories of organizations in both surveys and to set a limit as to the organizations that participate in policy governance, international organizations in the G-GEPON 2 were excluded, their network dimension was not investigated in J-GEPON 2 (in which 50 various organizations including international organizations among the 172 organizations were surveyed only for general questions). After deletion, out of a sample population of 122 organizations in Japan, 69 responses were obtained with 164 organizations, which excluded 19 international organizations. Second, we used the complete-case method, which is known as a listwise deletion of actors, to handle the missing data for the LR-QAP estimation. Huisman & Steglich (2008) note that this method removes both columns and rows for non-respondents. Although the result is smaller, the missing data is not considered a major problem in QAP regressions (Borgatti et al., 2018; Huisman & Steglich, 2008; Stork & Richards, 1992).

We then created 13 matrices for each country. To produce the matrices for factor (1), which is similarity of information type that the organization considers important, the organizations answered question 3 consisting of the four types of information: "How important is the following information about global warming/climate change for your organization? Please rank each information item using a scale from 1 (not important) to 5 (very important)." For make matrices to test hypothesis 1, the data was recoded in two steps. As the original data was ordinal with values 1 to 5, firstly, we combined the response values of 3, 4, and 5 as number1, and the response values 1 and 2 as number 0 to simplify the 1-to-5 scale. And finally, we recoded the matrices that each dyad received as number 1 if the two organizations have same number, and indicated zero otherwise. Also, for the factor (2) of similarity of the organization type that the organization considers important, the organizations answered question 4 with the four types of information: "For each type of information given below, please choose the type of organization which is an

important source of information for your organization." The data has values 1 to 12 by category. For making matrices to test hypothesis 2, we set symmetric matrices that the cell and its respondent cell are assigned the number 1 if the two organizations answered same category and zero if otherwise. Factor (3) regarding the information-sharing network and factor (4) regarding the resource-sharing network were combined to create matrices of two questions each. Factor (3) is a combination of question 7 (provide information) and question 8 (receive information). We transposed the matrix of question 8 and combined it with the matrix of question 7. Then the maximum value of the matrix was coded as 1. Thus, the information sharing network became the directed network as providing information. Questions (4) was processed in a similar manner.

Table 3. Network structural effect of the factor (3) based on the information sharing network

Network structural effects	Illustration	Explanation
Reciprocity		The tendency to reciprocate the receiving edge from another organization
Transitivity		The tendency to connect an edge with another organization with whom the organization has mutual edge
Preferential attachment		The tendency to connect an edge with another organization which is popular to whom the centered organization sends an edge

References: Borgatti et al. (2018), Kim & Kane (2015), and Kinne (2014)

Table 3 presents the network structural effects used as control variables of factor (3) based on the information-sharing network. Reciprocity is shown by the tendency to reciprocate the receiving edge from another organization. This matrix is created through transposing the information-sharing network matrix, so we need to pay attention to its interpretation, which is different from time-series data. In our data, to the extent that organizations have a tendency to reciprocate the receiving-information edge, we should find that in the sending resource edge in the resource-sharing network. It means it works if *organization i* receives information from *organization j* in the information-sharing reciprocity network; *organization i*, sends resources to *organization j* in the resource-sharing network. Through the transitivity matrix, we can find whether nonadjacent connections influence connecting adjacent connections in the resource-sharing network. Preferential attachment is collective adherence to social assessments (Borgatti et al., 2018). The core of the

preferential attachment is that people desire to identify and connect with other people who are considered most necessary as they are deemed to possess the most valuable information (Gould, 2002; Perry-Smith & Shalley, 2003). By the preferential attachment matrix, we can discover the popular organizations in the information-sharing network that can receive resources from many organizations in the resource-sharing network.

Results

The results of LR-QAP are presented in this section. Table 4 is an overview that shows the results of the complete LR-QAP model with coefficients, odds ratio, and significance level for each variable. We set the five LR-QAP models to test the hypotheses by applying the three factors of the informational dimension we have constructed. These models consist of the factors, i.e., similarity of information importance and information resource, and the information- sharing network. Models 1 to 3 examine the influence of factors separately first, and model 4 supportively tests the two similarity-of-information factors collectively. Model 5 is set to fully explain the hypotheses. Also, the latter two models function to compare effects among the factors by combining factors. In the explanation of these two models, higher values may can be obtained if we remove variables that are statistically insignificant, but the purpose is to compare how factors and variables affect the resource- sharing network, hence no variables were removed.

Table 4. Results of LR-QAP for resource sharing network

	M1				M2				M3				M4				M5			
	Germany		Japan		Germany		Japan		Germany		Japan		Germany		Japan		Germany		Japan	
	Coef	Odds R	Coef	Odds R	Coef	Odds R	Coef	Odds R	Coef	Odds R	Coef	Odds R	Coef	Odds R	Coef	Odds R	Coef	Odds R	Coef	Odds R
International activities (I)	0.277	1.319	0.107	1.113									0.453	1.572	-0.157	0.855	0.076	1.079	0.302	1.353
Domestic activities (I)	0.070	1.073	0.536	1.709									-0.543	0.581	0.806	2.239	-0.965	0.381	0.687	1.988
Science and technology (I)	1.045**	2.845	-0.369	0.691									0.916*	2.498	-0.112	0.894	0.980*	2.666	-0.864	0.422
Society and the economy (I)	-0.344	0.709	1.063**	2.894									-0.250	0.779	0.853	2.347	-0.199	0.820	1.038	2.824
International activities (S)					0.233	1.263	0.563	1.755					0.202	1.223	0.539	1.715	0.116	1.123	0.467	1.594
Domestic activities (S)					0.030	1.030	0.063	1.065					-0.062	0.940	0.166	1.181	-0.075	0.928	0.398	1.489
Science and technology (S)					0.077	1.081	-0.159	0.853					0.051	1.052	-0.222	0.801	0.045	1.046	-0.240	0.786
Society and the economy (S)					0.304	1.355	-0.157	0.855					0.282	1.326	-0.130	0.878	0.089	1.093	-0.107	0.898
Information network									0.806**	2.238	4.291***	73.076					0.822**	2.275	3.718***	41.170
Reciprocity									3.286***	26.744	-0.135	0.874					3.242***	25.578	0.248	1.282
Transitivity									0.047**	1.048	0.012	1.012					0.049*	1.050	0.007	1.007
Preferential attachment									-0.034**	0.967	-0.008	0.992					-0.038**	0.963	0.006	1.006
R-square		0.013		0.004		0.002		0.003		0.070		0.065		0.011		0.010		0.082		0.095
p-value		0.456		0.964		0.118		0.867		0.000		0.000		0.105		0.891		0.001		0.323
N of Permutaions		100000		100000		100000		100000		100000		100000		100000		100000		100000		100000

Note: Significance at (<=0.05 (*), <=0.01 (**), <=0.001(***)) are shown with asterisk(s) and are the rows are colored gray with the dependent variable as the resource-sharing network. (I) indicates similarity of information importance and (S) indicates similarity of information resource.

First, model 1 and 2 are the models to test hypothesis 1 and 2 of information homophily factors, respectively. Both sets of results, including p-values of the factors, are too large to be insignificant and the R-square values of the factors are very low in overall. Thus, these do not explain the two models in both counties. Nonetheless, one point in the results for model 1 is of note: The comparison among the variables in factor (1) led to the discovery that the organizations consider information about science and technology to be important, positively influencing resource sharing in Germany. In Japan as well, similar attitudes towards information about society and the economy influences resource sharing. Other types of information are not significant to explain the relationship to the dependent variable in model 1, and in model 2 neither is significant. Model 4 shows the results of hypotheses 1 and 2 for information homophily factors that were tested collectively. Similar to the results of models 1 and 2, the results for model 4 are not statistically significant (p-values > 0.05 in both countries) in both countries. In addition, as with model 1, the homophily of information about science and technology is still significant, but the variable of the homophily of information about society and the economy having an influence on resource sharing is not significant in the collective model.

Second, model 3 is set for testing hypothesis 3. The last hypothesis, which predicts that connectivity in the information-sharing network increases connectivity in the resource-sharing network, is confirmed (p-values < 0.001 in both countries). However, in looking at the R-square values, they are not fully able to explain the resource-sharing network in both countries (Germany: 0.070, Japan: 0.065) with this model as well as the other models. In Germany, all of the set variables indicate that the structural effects are very significant (p-values are <0.000 ~ <0.009). In terms of the results, notably, the information-sharing network, the tendency of reciprocity and the tendency of transitivity return a positive influence, but the tendency of preferential attachment does not. It means that the organizations that send information to popular organizations in the information-sharing network provide resource to nodes that are not well connected. In the case of Japan, only the information-sharing network is significant.

Finally, model 5 was considered the main model for testing the hypotheses. Basically, Model 5 is acceptable only in Germany, and in the case of Japan, the p-value is too high (p-value = 0.323). Hypothesis 1 assumed that the similarity of information type that organizations consider important between two organizations in the information-sharing network increases connectivity in the resource-sharing networks. However, the results were statically significant only with reference to information about science and technology (coefficient = 0.980, p-value = 0.017) in Germany; on the other hand, none of the results were significant in Japan, as seen by the results of model 4. Hypothesis 2 predicted that the similarity of the organization type that the organizations consider important information source between two organizations in the information-sharing network increases connectivity in the resource-sharing network, but the results did not confirm the hypothesis, as reinforced by model 4. Any similarity to information sources can affect resource-

sharing networks. Hypothesis 3, the last hypothesis assumed that connectivity in the information-sharing network increases the connectivity in the resource-sharing network. This hypothesis was confirmed by the results in Germany, and it was partially confirmed in Japan. Every variable in the information network factor is statistically significant in Germany. In the variable about the tendency of connectivity, only preferential attachment, which is the only negative effect in all of the significant variables in both countries, affects negatively. It may be the case in Japan that there is no significant variable about the tendency towards connectivity except the variable of the information-sharing network.

Additionally, among the three factors, the information-sharing network factor is exceptionally important in understanding the resource-sharing network in the informational dimension in both countries. After this factor (3) is added, the R-square value greatly increases compared to model 4 (0.011 to 0.082 in Germany and 0.010 to 0.095 in Japan). Furthermore, the influence of the informational dimension becomes more significant in Germany than when it is not added. The case of Japan, however, still cannot be explained because the p-value is too high.

Discussion and Conclusion

The purpose of this study was to investigate the structure of environmental policy governance as collaborative governance by analyzing the relationship between the informational dimension of governance networks and its complement resource-sharing networks in Germany and Japan.

In order to achieve this purpose, three factors were analyzed in both Germany and Japan using LR-QAP. First, we estimated the causal relationship between the similarity of information types, which are considered to be important to organizations, and the resource-sharing networks. We also conducted an analysis of the influence of similarity of the category of organization, considered to be an important source of information in the resource-sharing network. As observed, the results of these two factors answered the first research question as being almost untenable in that similarity factors in the informational dimension in governance "does not" influence the resource-sharing network in the governance networks in Germany and especially Japan. Second, our analysis revealed that the information-sharing networks have lower-level network influence on the resource-sharing networks as higher-level networks within the continuum. According to the results, the information-sharing relations and the measures of reciprocal and transitive tendency increase the resource-sharing relations in the network, but preferential attachment in the network's structural effects leads to a negative effect in the resource-sharing relations in Germany. Japanese information-sharing relations also tend to increase the resource-sharing relations, but structural effects do not. We believe that these results are unable to explain this phenomenon sufficiently, leading us to believe that there is another piece of the puzzle that we have not measured. Nevertheless, our results suggest that the information-sharing networks may be one of the pieces of this puzzle. Particularly, in accordance with the results of model 5, at least the German information-sharing network shows this tendency, even if the Japanese results do not.

The values of this study lie in analyzing the possibility of developing governance through the perspective of collaborative governance focusing on relational characteristics of the informational dimension among actors with resource-sharing networks in the environmental policy governance in Germany and Japan. However, this study still has several limitations that need to be addressed in future research. First, we did not include the dimension of demographic attributes such as organizational category, year of establishment, geographical location, and participation in COP, as well as another dimension for uncovering how information-sharing networks as lower-level networks influence the resource-sharing networks as higher-level networks. As this study focused primarily on the informational dimension, we admit that this omission probably could affect our results. Second, we used the complete-case method for handling missing data, but the complete-case method has a recognized weakness in creating smaller networks once non-respondents are removed. This could also affect the results, which could be biased because the sample of the remaining nodes is not representative enough. However, this may not be a major issue at the dyadic level (Borgatti et al., 2018; Schafer & Graham, 2002; Stork & Richards, 1992). For this reason, other imputation methods should be attempted to test the possibility of reducing such bias in the results Lastly, the data we use to investigate the environmental governance is not longitudinal. We already have survey data in both countries, yet the data is of limited usefulness. Thus, further research using a longitudinal analytical approach with the former datasets of G-GEPON 1 and J-GEPON 1 (similar surveys conducted in the late 1990s and early 2000s) can identify and analyze environmental governance, and it is possible that such further analysis with help uncover unobservable contextual findings from cross-sectional and comparison of the two countries.

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Appendix

This table is the results of the model 5 by MR-QAP as follow. As the full model, the model 5 utilizing MR-QAP generates the results of an R-square value as 0.06807 (0.082 from LR-QAP), and specifically, the same variables with the results of the LR-QAP are significant in Germany. In Japan, the R-square value yielded as 0.07729. It is slightly lower than the LR-QAP (R-square: 0.095), and only information-sharing relations influence the resource-sharing network in the same manner as the result by LR-QAP.

Table 5. Results Model 5 by MR-QAP for resource sharing network

	M5	
	Germany	Japan
	Stdized Coef	Stdized Coef
International activities (I)	0.007(0.422)	0.007(0.452)
Domestic activities (I)	-0.044(0.136)	0.036(0.208)
Science and technology (I)	0.081**(0.006)	-0.039(0.172)
Society and the economy (I)	-0.027(0.205)	0.052(0.133)
International activities (S)	0.009(0.316)	0.044(0.062)
Domestic activities (S)	-0.006(0.433)	0.028(0.208)
Science and technology (S)	0.007(0.364)	-0.013(0.223)
Society and the economy (S)	0.013(0.270)	-0.006(0.383)
Information network	0.069**(0.004)	0.244(0.000)***
Reciprocity	0.161***(0.000)	0.028(0.141)
Transitivity	0.105*(0.013)	0.023(0.173)
Preferential attachment	-0.100**(0.008)	0.004(0.425)
R-square	0.06807	0.07729
N of Permutations	100000	100000

Note: The values in the brackets are *p*-value and significance at (<=0.05 (*), <=0.01 (**), <=0.001(***)) are shown with asterisk(s) and are the rows are colored gray with the dependent variable as the resource-sharing network. (I) indicates similarity of information importance and (S)