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Information exchange in governance networks—Who brokers across political divides?

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Abstract

The exchange of information among organizations is the lifeblood of governance networks. It is a necessary condition for successful governance. Political divides between organizations often impede information exchange. We ask which organizations are most likely to broker information across political divides. We consider survey ($n = 312$) evidence of technical information exchange in Swiss water governance. Bayesian exponential random graph modeling results show that scientific organizations play crucial roles for cross-divide brokerage. To a lesser extent, this also holds for higher-level governmental agencies. Participation in policy forums is associated with a higher likelihood of brokering across political divides. There is however no clear benefit to participating in more than two or three forums. We conclude that an active role played by scientific organizations is the most promising avenue to increase information flow across political divides. Beyond this, we suggest setting up carefully constructed exchange forums and selectively engaging moderate members of subgroups.

1 | INTRODUCTION

The exchange of information is an essential component of how actors interact in governance networks. Through information exchange, actors can reduce their uncertainties regarding different governance challenges and thus improve decision-making processes (Pahl-Wostl, 2007).

Extensive information exchange is particularly important in complex systems with ever-changing conditions and in systems with high levels of uncertainty regarding which future steps should be taken to ensure a positive impact on the system (Pahl-Wostl, 2007). Information exchange is also the basis for policy learning and has been shown to be more effective if information sources are diversified (Newig et al., 2010). Furthermore, information exchange can promote common problem perceptions, which in turn facilitates decision making (Cash et al., 2003).

We understand governance to take place in an interorganizational network (Rhodes, 1996), dealing with a set of substantive collective action problems within a geographically limited territory (Lubell, 2013). Recognizing the importance of information exchange in interorganizational governance networks, a growing body of literature has been studying the factors that shape, advance, and impede information exchange in different policy fields (Fischer et al., 2017; Leifeld & Schneider, 2012; Wagner & Ylä-Anttila, 2018). Among factors that impede information exchange, the influence of political division stands out. Organizations on different sides of political divides, holding differing beliefs about fundamental values and preferences for policy solutions, are less likely to exchange information than actors on the same side of a political divide (Leifeld & Schneider, 2012; Wagner & Ylä-Anttila, 2018). In this article, we turn to analyze potential remedies to increase information exchange in the presence of political division. We focus on technical information exchange in this regard, as we see strong normative arguments for ensuring a high level of permeability for technical information within complex governance systems. As a specific remedy, we investigate organizations that exchange technical information across political divides within Swiss water governance, a real-world empirical example of a complex governance system.

We single out organizations that play an outsize role in increasing the flow of information across political divides for analysis. These broker organizations facilitate the exchange of information between organizations with differing views. We therefore ask:

> Which organizations are most likely to broker information exchange across political divides in complex governance systems?

In a case study of Swiss water governance, we empirically investigate two attributes of organizations to determine their influence on the likelihood of an organization to play a cross-divide broker role. First, we study differences among organizational types, comparing scientific organizations, state and national administration, interest groups, service providers, and local municipalities. Second, we examine the influence of policy forum participation—a controversially discussed means to increase cross-sectoral exchange (Fischer & Leifeld, 2015; Wagner & Ylä-Anttila, 2018)—on bridging across divides.

By investigating the specific and crucial actor role of brokerage across political divides, we contribute to the existing literature on knowledge brokering (e.g., Cash et al., 2003; Vignola et al., 2013), policy networks (e.g., Henry et al., 2011; Leifeld & Schneider, 2012), and policy forums or venues (Fischer & Leifeld, 2015; Lubell, 2013).

We also provide policymakers with a list of most likely targets to engage with in order to increase the flow of information within a complex, multidimensional governance network.

Our empirical data stems from a nation-wide study of organizations involved in Swiss water governance.

2 | THEORY

2.1 | Political division and information exchange governance networks

Information exchange in governance systems is a relational social phenomenon that can be helpfully described and analyzed as a network. Previous studies within the policy network literature have identified a set of general driving forces behind the establishment of information exchange ties (Leifeld and Schneider 2012). Among those driving forces, the influence of political division stands out.

There is long-standing and rich empirical evidence documenting that policy networks in general are dis-proportionally shaped by belief similarity (Henry et al., 2011; Ingold & Fischer, 2014; Weible & Sabatier, 2009; Zafonte & Sabatier, 1998). Key contributions about the theoretical mechanisms behind these findings have especially come from studies carried out within the Advocacy Coalition Framework (ACF) (Weible & Sabatier, 2007).

Belief similarity leads actors with similar beliefs to group together. The ACF organizes beliefs in a hierarchical system. Beliefs range from deeply held, very stable deep core beliefs, normative convictions, or worldviews, over policy beliefs tied to issues within a given policy subsystems to less stable secondary aspects describing preferences regarding specific solutions to address policy issues (Weible & Sabatier, 2007). Shared beliefs are major drivers of coalition structure and collaboration in policy subsystems (Ingold & Fischer, 2014), especially in adversarial subsystems (Weible & Sabatier, 2009).

2.2 | Technical information exchange networks

The well-documented influence of belief similarity on the likelihood of information exchange in governance networks presents a major problem for successful governance outcomes (Ingold et al., 2019). We focus our attention in this study specifically on the exchange of technical information.

Information exchange networks are shaped by the type of information that is being transmitted within them. Generally, studies on information exchange in policymaking differentiate two broad categories (Fischer et al., 2017; Leifeld & Schneider, 2012; Weible & Sabatier, 2009): On the one hand, there is strategic or political, more subjective information. Governance in many fields, such as the environment, public health, or security, involves a host of normative questions of profound subjectivity (such as the value of preserving a single species or triage procedures). Information about the general stances of other actors regarding such questions, or information about ongoing developments within a governance subfield can be considered more political or strategic knowledge. On the other hand, there is technical, evidence-driven, generally considered more objective information. Such information may, for example, include the results of hydrological modeling, outcomes of medicinal trials, or crime statistics.

The differentiation between political and technical, or subjective and objective information can be fuzzy in real-world situations. Nonetheless, it has been shown to have an effect in shaping information exchange networks. In general, the influence of political division impacts the exchange of political information more strongly, but also exist for technical information exchange (Fischer et al., 2017; Leifeld and Schneider 2012).

We are motivated by explicitly normative considerations in our focus on the influence of political divides on technical information exchange. We suggest that it is especially worrisome if exchange regarding objective, evidence-based information is influenced by differing political preferences among organizations. The value of such information is largely tied to its claims to be intersubjective. Differences in policy beliefs should thus not influence the sharing of neutral information between actors. If they do, it is likely that detrimental results for the quality of governance occur. There are three main reasons for this.

First, decisions taken by actors within governance networks are likely to be more legitimate and have a broader impact if they reflect a broader set of views rather than incorporating only the views of a subgroup (Barnes et al., 2016; Yi, 2017). Polarized information exchange within governance systems may lead to a higher chance of rejection of decisions taken by policymakers, as these decisions do not take into account diverging views, and are at the same time not taken to be legitimate by an excluded segment of organizations.

Second, actors involved in governance lose access to valuable sources of knowledge if they only receive information from a subset of like-minded others (Armitage et al., 2008). In such settings, information can become sticky (Burt et al., 2013), making it hard for valuable technical information to cross among clusters of like-minded actors.

Third, governance takes place within complex systems, where likely outcomes of decisions are often not readily apparent (Byrne & Callaghan, 2014). Even though decisions must be taken nonetheless, a key focus of policymakers in complex systems should also lie on shaping and understanding the environments they operate in (Haynes, 2015). One key characteristic that should be increased in this regard is the capacity for systems to be resilient and adaptive. Ensuring that the flow of information, or generally connectivity (Ingold et al., 2019) within a governance system is not impeded by political divides can contribute to this. It makes sure that new information about emerging problems as well as information about solutions is more quickly distributed within the system.

2.3 | The role of bridging organizations

We feel that recently suggested calls for policy analysis to its normative, problem-oriented roots (Cairney & Weible, 2017) also extend to governance network analysis. Therefore, this article goes beyond providing evidence that exchange of technical information is far from perfect and influenced by political beliefs. Instead, we study organizational roles that can help overcome this situation and suggest most likely candidates for doing so.

Political division creates fragmented governance networks. A major remedy to overcome fragmentation within a governance system is likely to be found in bridging organizations (Angst et al., 2018), providing bridges between more tightly clustered communities of actors, akin to the weak ties in Granovetter (1973).

We suggest that identifying and strengthening bridging organizations is likely to be an effective and efficient way of improving information exchange. It is efficient as it requires targeting only a subset of all organizations involved in governance, and effective as it targets organizations that have an outsize role in improving exchange.

We focus on cross-divide brokers as a special kind of bridging role. These are effective relay stations passing information between groups of organizations with differing political beliefs and preferences. The general broker concept is ubiquitous in the social network literature (Gould & Fernandez, 1989). Generally, the defining characteristic of a broker lies in connecting

organizations, which would otherwise not be connected. A brokerage role can be broken down to the configuration of relations between three actors, whereas information flows from an actor *i*, or sender, via a middle actor (the broker) *k* to another actor *j*, or receiver. Such a configuration is also called a directed two-path.

In our case, we are especially interested in brokers that establish connections between organizations with different policy beliefs, whether they are part of these groups or not, illustrated in Figure 1a,b.

2.4 | Characteristics of likely cross-divide broker organizations

We expect the likelihood to play a broker role to differ between different organizations. We focus on two characteristics of organizations in this study in this regard, organizational type and forum participation of organizations.

Organizational type refers to archetypal categories of organizations, representing organizational kinds occurring in many governance systems. These are municipalities, higher-level administrative agencies, interest groups, service providers (public or private utilities), private firms, and scientific organizations (such as applied or university-based research groups, and scientific associations). We expect the likelihood for cross-divide brokerage to vary in predictable ways among different types of organizations.

For higher-level administrative agencies, we except an above average tendency for cross-divide brokerage to occur. Studies within the ACF usually associate them with moderate policy positions and broker roles between opposing coalitions (Leifeld, 2013). Higher-level administrative agencies play a crucial role in governance networks as preferential targets for collaboration (Ingold & Leifeld, 2014; Leifeld and Schneider 2012), as they often possess significant expertise and formal decision-making power. It is likely that the generally high involvement of higher-level agencies in governance networks raises the baseline probability for them to broker across political divides. It is further likely that higher-level agencies perceive such brokerage specifically as their task, especially in settings where decentralized forms of governance are emphasized (Klijn & Koppenjan, 2000). Playing broker roles in general allows higher-level agencies to exert indirect control over governance outcomes by putting themselves in indispensable

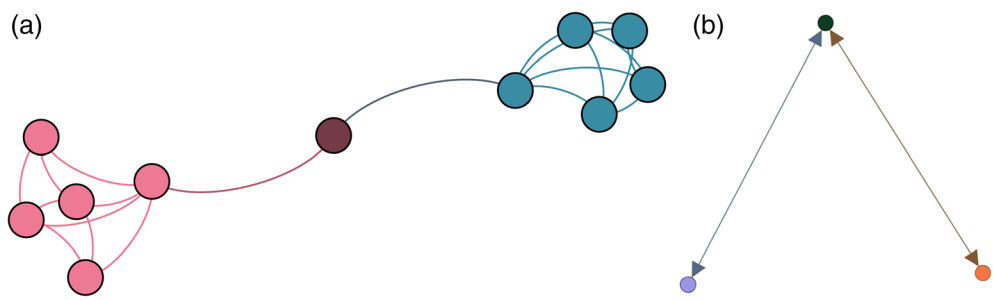

FIGURE 1 Broker positions in information exchange networks. (a) Simple illustration of a broker position (black node), including all possible directed two-paths running through the broker. (b) Stylized cross-divide broker position within a larger network. The black node is placed in a broker position between the red and blue groups

coordinating positions (Fliervoet et al. 2015) and this is likely to extend to the specific role of brokering technical information across political divides.

Hypothesis 1a. *Higher-level administrative agencies are on average more likely than other organizations to broker information across political divides.*

We do not see it as especially likely that scientific organization play an important role with regard to the transmission of technical information across political divisions. Scientific organizations often see themselves as neutral arbiters of truth, "honest brokers" (Pielke, 2007) outside of the policy process. They should thus follow organizational logics well suited to engage with organizations holding different policy beliefs in networks (Weible & Sabatier, 2009). However, they are often knowledge sources and providers of knowledge, which is taken up selectively by other organizations (Leifeld, 2013). The self-conception of many scientific organizations does not make them likely bridges transmitting (compared to providing) information between other sources of information.

Hypothesis 1b. *Scientific organizations are on average less likely than other organizations to broker information across political divides.*

Our argument regarding the likelihood for private sector organizations to broker information across political divides rests mainly on transaction costs organizations face in establishing and maintaining ties in networks (Leifeld and Schneider 2012). Specifically establishing ties brokering information across divides can introduce significant costs to organizations in terms of time and personnel occupied. Private sector organizations are unlikely on average to see it as their organizational purpose to create cross-divide brokerage ties. We do not expect private sector organizations under market pressures to play a significant role in brokering across divides for this reason.

Hypothesis 1c. *Private sector organizations are on average less likely than other organizations to broker information across political divides.*

Interest groups play a special role in theories of the policy process such as the ACF. Together with political parties, they are often at the core of coalitions in adversarial policy subsystems (Ingold, 2011), holding the most extreme beliefs among coalition members. If interest groups are on average likely to hold more extreme beliefs than other organizations, this reduces their likelihood to engage in information exchange with organizations holding different beliefs in turn (Leifeld and Schneider 2012) making them unlikely cross-divide brokers.

Hypothesis 1d. *Interest groups are on average less likely than other organizations to broker information across political divides.*

Municipalities play an important role in governance networks. They are often the last instances implementing and translating policies into concrete action (Mancilla García et al., 2019). We expect municipalities to be unlikely to play cross-divide brokerage roles for this reason. We have hypothesized above that scientific organizations are unlikely brokers because they are often likely sources of information. Conversely, municipalities are often likely end points for information flows, making them unlikely brokers as well.

Hypothesis 1e. *Municipalities are on average less likely than other organizations to broker information across political divides.*

A much-touted remedy to increase the flow of information within governance systems have been policy forums. Policy forums are specific venues in governance systems that aim to increase interaction and exchange between actors from different sectors (Fischer & Leifeld, 2015). Given that ensuring information flow and finding common ground among different participants is often a stated objective of policy forums (Fischer & Schläpfer, 2017), we would expect a positive effect of forum participation on cross-divide brokering of organizations. The cross-sectoral nature of policy forums increases the likelihood for organizations with divergent policy beliefs to exchange information. If organizations provide information they have acquired in forums to other information they interact with outside forums, they become likely cross-divide brokers.

Hypothesis 2a. *Higher forum participation of an organization makes an organization more likely to broker information across political divides.*

Recent evidence from Irish climate policymaking has questioned the effectiveness of policy forums to encourage exchange among dissimilar organizations. Organizations did not show clear patterns of learning from alternative viewpoints or information present through forum participation (Wagner & Ylä-Anttila, 2018). If these results are indicative of a broader pattern, they suggest that organizations who participate in forums do engage substantially less than envisioned by forum organizers with what they encounter in forums. In turn, this would decrease the likelihood for forum participants to broker information to others across divides, suggesting an alternative hypothesis.

Hypothesis 2b. *Higher forum participation of an organization does not make an organization more likely to broker information across political divides.*

3 | DATA GATHERING AND METHODS

An anonymized version of the data set we used in this article as well as code enabling the replication of our analysis is provided in an open online repository under https://doi.org/10.5281/zenodo.4626528.

3.1 | Case

We study Swiss water governance in a broad sense, including all explicitly water-related governance issues within the territory of Switzerland, following arguments for the increased study of trans-subsystem dynamics in governance (Jones, 2009), which we deem especially important for information exchange networks. Surrounding these issues, we specifically study the technical information exchange network between organizations involved in them, on all levels of a scale reaching from national, cantonal,[1] regional[2] to municipal.

Water governance systems as parts of larger social-ecological systems surrounding water resources are typical examples of complex, multidimensional governance systems

(Tropp, 2007). This is fundamentally due to the multidimensional character of the resource water itself. Humans use water (such as in drinking water or to produce hydroelectricity), need to be protected from water (as in protection against flooding), while water itself needs to be protected from some human inputs (such as pollution). A complex network of organizations with at times differing goals address water governance issues on different levels and through different activities, ranging from planning to implementation and evaluation (Angst, 2020).

On top of the complexity inherent to the social system involved in water governance, water systems itself are complex biophysical systems where the effects of decisions are often surrounded by uncertainty in terms of outcomes, as well as on other parts of the system. This setting makes the exchange of technical information crucial in water governance. For example, when implementing new flood protection measures, such as the building or extension of a dam, effects on aquatic ecosystems need to be considered. Therefore, knowledge of local nature protection organizations, scientific assessments, or guidelines provided by environmental protection agencies can be helpful sources of technical information. If there is no access to these sources, unintended, costly, and at worst irreversible outcomes might emerge, such as the destruction of important aquatic habitats.

3.2 | Data gathering

We understand water governance broadly to include a number of different, overlapping policy subsystems centered on different substantive collective action problems involving water in some way. We gathered data about technical information exchange in a nation-wide online survey of 476 organizations involved in Swiss water governance.

Organizations included a wide range of organizational types, such as administrative agencies, interest groups, service providers, or engineering firms. The starting sample of organization to whom the survey was sent in a first round was based on an extensive document analysis of newspaper articles and parliamentary protocols on the national and cantonal level. We manually coded the occurrence of organizational actors and water governance issues in documents found with a keyword search (water, lake, and waterbody) for the year 2013 (for details on the document analysis, see Brandenberger et al., 2021).

To gather data about technical information exchange in the survey, we asked organizations to name the most important organizations they provided with water-related technical information, as well as the most important organizations they received information from over the course of the 3 years preceding the survey. We specified technical information as domain knowledge[3] and listed technical engineering knowledge or biological and ecological basic knowledge[4] as two concrete examples.

Each organization was also asked to list other organizations they considered allies or opponents in each group of water governance issues they indicated to be active in (see Supporting Information for a list of issues). To gather policy beliefs, we asked organizations to state their level of agreement or disagreement on a 4-point scale[5] regarding a number of salient policy debates in Swiss water politics, such as minimizing fertilizer input into streams or the trade-off between landscape protection and large-scale hydropower construction. Further survey questions of relevance in the context of this study included organizational expertise, where organizations were asked to state different types of expertise they possessed (such as engineering, ecological, management, or lobbying), as well as their participation in a list of different policy

forums existing in Swiss water governance (Fischer & Schläpfer, 2017). We provide summary information on policy beliefs, expertise, forum participation, and issue involvement in the Supporting Information.

We conducted a first survey round in summer 2016 (sent out to 406 organizations, response rate 69%). We followed up the first round with a snowballing round. In the snowballing round, we sent the survey to all organizations (not included in the first round), who were named as allies, opponents, or information exchange partners in the first round (sent out to 70 organizations, response rate 64%).

All organizations received two reminders. We followed up nonresponses or partial responses with telephone interviews to complete the data as much as possible. A previous analysis of other aspects of the data set indicates that nonresponse was evenly distributed across organizational categories, with a slight under-representation of political parties and private sector actors (Angst, 2020).

Of the total of 326 respondent organizations, in a small number of cases, multiple people within an organization responded to the survey. In these cases, we aggregated answers for this study, leading to a final *n* of 312 respondents.

Of these 312 organizations, 184 organizations indicated a total of 330 information exchange ties with other survey participants in our sample. Beyond this, an additional 490 ties were reported with organizations that did not participate in the survey.

3.3 | Identifying divisions in Swiss water governance

We first assess the amount and makeup of division that exists within the Swiss water governance system and can be inferred from our data, before proceeding with an analysis of cross-divide bridging activities.

We follow the ACF literature in evaluating political division in Swiss water governance using a combination of policy beliefs and allies/opponent relations (Ingold, 2011), which we integrate in a shared dissimilarity metric. We create a measure of dissimilarity in policy stances between each pair of a total of 312 survey respondent organizations. To create the dissimilarity measure, we use Gower's distance (Gower & Warrens, 2017) as implemented in the R package cluster (Maechler et al., 2021). Gower's distance makes it possible to assign equal weight to each organization's belief configuration and its configuration of allies and opponents.

To identify clusters of organizations in Swiss water governance, we use this dissimilarity matrix in policy stances based in a k-medoids clustering approach (details on the dissimilarity measure and cluster solution are provided in the Supporting Information).

3.4 | Modeling cross-divide brokerage using Bayesian exponential random graph models

We assess the likelihood for different types of organizations to exchange information across political divides using Bayesian exponential random graph modeling.

Exponential random graph models (ERGMs), both in their Bayesian (Caimo & Friel, 2011) and non-Bayesian form (Cranmer et al., 2017; Robins et al., 2007), are a type of network inference model which can be used to determine which combination of factors are most likely to

explain the structure of an observed network. Our main interest is to see which organizations are likely to pass information between organizations with diverging political views. ERGMs are preferable over standard regression models as they account for the dependence in the observations (Cranmer et al., 2017).

We use ERGMs in their Bayesian form. Bayesian ERGMS (BERGMs) offer the inherent features of Bayesian approaches, such as the intuitive interpretation of parameter estimates as posterior distributions, together with considerable promise in alleviating common ERGM problems such as computational tractability, degeneracy, and interpreting parameter estimates (Caimo et al., 2017). To ensure the model adequately represents endogenous processes in our data, we perform goodness-of-fit tests (see Supporting Information).

3.5 | Cross-divide bridging parameter

We operationalize cross-divide information exchange in the form of a closing two-path statistic, based on a new ERGM parameter we developed within the framework provided by the ergm.userterms R package (Hunter et al., 2013).

The closing two-path statistic computes for every organization k the sum of difference on a given metric (here the dissimilarity in political stances d between all the startpoints and end points of every directed two-path the organization k is in the middle of. For example, an organization k receiving information from one organization i and passing it on to two organizations j_1 and j_2 with differences $d_{i,j1} = 0.5$ and $d_{i,j2} = 1$ would contribute to the statistic with $d_{i,j1} + d_{i,j2} = 1 + 0.5 = 1.5$.

We develop our closing two-path statistic as an interaction term. This allows us to specify an additional categorical actor attribute for the broker actor k. If specified, the statistic is computed separately for all categories of the actor attribute, based only on actors matching the attribute. As such, it allows us to assess the likelihood of certain actor groups to be involved in more cross-difference brokerage, compared to a baseline category. The tie-level interpretation of the parameter refers for every category of actors to the ceteris paribus likelihood of a tie forming depending on the amount of difference it would bridge if it was to close a two-path. We included an interaction with the organizational types we formulated hypotheses for (taking all others as baseline), as well as an interaction with forum attendance split into ordinal categories of no forum attendance, attending one forum, attending two to three forums and attending many (four or more) forums (with no forum attendance as baseline).

The inclusion of an interaction term makes it necessary to include its constituent terms or main effects. To do so, we include (a) activity and popularity terms for the actor types and ordinal forum categories we had developed hypotheses for, (b) homophily effects for shared type between organizations and the number of shared forums, (c) a term for the general likelihood of a two-path closing tie, (d) a term for the influence of endpoint policy stance dissimilarity on closing a two-path, and (e) a term covering the influence of policy stance dissimilarity on a tie in general.

3.6 | Additional covariates

We include four model terms in our BERGM to account for different network-endogenous and exogenous factors shaping the tie distribution of an actor and potentially interfering with

inference regarding our hypotheses. Endogenous factors do not depend on actor attributes, but rather on the network structure. We include these terms mainly for model fit, not due to explicit causal considerations.

We include terms modeling triadic closure, the indegree distribution, and the outdegree distribution of the network (Hunter, 2007). We also include an edges term, similar to an intercept in standard regression models, which models the average density of the network.

We also included two network-exogenous factors depending on actor attributes. These are dissimilarity (Manhattan distance) in expertise[6] for two organizations k and j and issue similarity, the number of shared water governance issues both organizations are active in.

We decided to include the two network-exogenous covariates based on a directed acyclic graph (DAG) (Pearl, 2009) which formalizes how we understand the causal structure of interrelations among our variables (see "Causal model (DAG)" section in Appendix for a graphical representation of our DAG and dagitty [Textor et al., 2016] code in the Supporting Information). Given our DAG, the inclusion of expertise dissimilarity and issue similarity is necessary to estimate the direct causal effect of forum participation on cross-divide brokerage. For the influence of actor type, it is not necessary. In both cases, the inclusion of the covariates does not introduce bias or confound our main causal pathways of interest, given our DAG (Shrier & Platt, 2008).

3.7 | Modeling approach

The hypotheses we test in the BERGMs model the interplay between organizational attributes (beliefs of organizations) and network structure (brokering). As previously outlined, during the survey, inadvertently, some respondents named information exchange partners of which we had no survey data as they were either not included in the survey or did not respond. This is crucial, because we could only establish policy belief similarity for pairs of actors we had survey data on.

The data available to us for modeling thus consisted of two data sets. First, information exchange network data on both survey participants and nonparticipants (520 organizations, 820 ties), together with attribute data on organizational type for all organizations. Second, a subset of this data, containing the network between survey participants (184 organizations, 330 ties), together with the full attribute information from the survey.

For the clustering step to identify overall patterns of division, we use only the second data set. In our BERGM modeling, to make full use of the data available, we take a two-step approach. In a first model, we model the larger data set to estimate posterior distributions for the four network endogenous terms and all terms related to actor type (activity, popularity, and homophily). We then used these posterior distributions (see Figure A2 in the appendix) to set priors for these terms in a second model of the smaller data set, which also adds terms based on survey information to evaluate our hypotheses.

We used a mix of prior information based on previous research on governance networks, while setting a vague prior distribution for parameters where pre-existing information was not available (see Supporting Information for detailed information about the exact prior distributions used and their justification).

4 | RESULTS

4.1 | Division and information flows in Swiss water governance

We found three distinct clusters of organizations with regard to their policy stances within Swiss water governance. Based on an examination of the distribution of policy beliefs in each cluster (see Table A1 in Appendix), a first cluster ($n = 71$) represents a broadly pro-ecology cluster intent on reducing fertilizer input into watercourses, preventing new hydropower plants and giving consideration to the impact of flood control measures on aquatic ecosystems. The pro-ecology cluster contains the largest shares of interest groups (39%), state agencies (21%), and scientific organizations (14%) of any cluster. A second neutral/administrative cluster ($n = 106$) represents a number of organizations with more middling beliefs. It contains the largest proportion of private sector actors (20%) and service providers (14%) of any cluster. A third, more pro-(economic) development cluster ($n = 135$), in contrast, views especially the construction of new hydropower capacity of all sorts much more favorably. It is dominated by municipalities (32%), private sector actors (18%), and service providers (13%).

Figure 2 illustrates how information in Swiss water governance is exchanged within and across the three clusters we identified on aggregate. Within-cluster exchange exceeds outgoing ties to and incoming ties from other clusters for both the pro-ecology and administrative clusters. Both clusters, however, share a significant amount of information with each other. The pro-development cluster plays primarily a role as information provider to the other clusters. Overall, within-cluster ties amount to 42% of total ties.

Figure 3 shows the number of times an organization k assumes a broker position between organizations i and j and plots the difference in political stance between i and j. Overall, state administration offices are the most active brokers, whereas local administration offices hardly ever broker. The political distances the brokers are able to span vary greatly. However, care needs to be taken not to overinterpret these descriptive results, as they do not account for main effects, such as the overall prevalence and differences in activity or popularity among actor types.

4.2 | Bridging organizations in Swiss water governance

Figures 4 and 5 report the implications of our BERGM models for our hypotheses. The figures show the change in posterior predicted probability of an information exchange brokerage tie

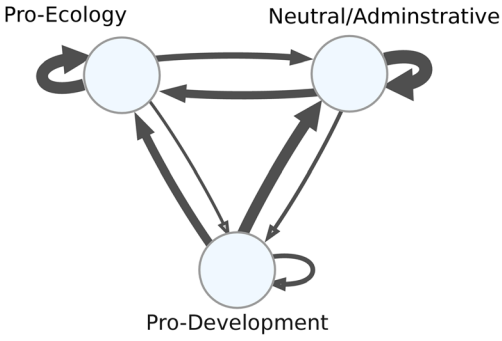

FIGURE 2 Aggregated information flow ties within and between clusters of similar organizations in terms of policy stances in Swiss water governance. Arrow width is proportional to the number of information exchange ties

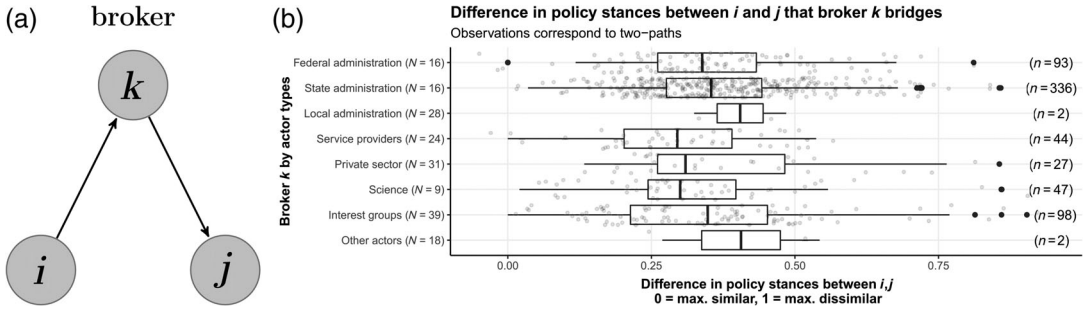

FIGURE 3 Brokering information exchange. (a) Two-path where organization k brokers information exchange between organizations i and j. (b) Difference in policy stances between organizations i and j that broker k has to bridge. N refers to the total number of organizations of the respective organization type. n refers to the total number of two-paths all organizations from one actor type form in the network. For example, there are 16 state organizations in the data set and they form 336 two-paths (= bridges) between other nodes

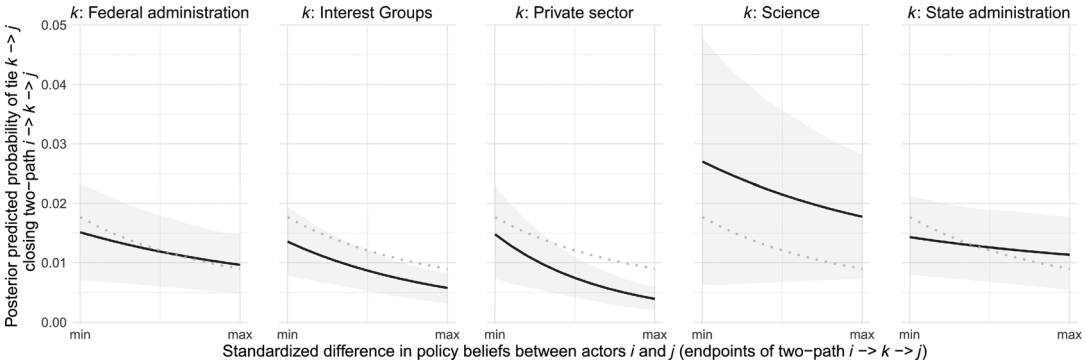

FIGURE 4 Impact of broker type on cross-divide bridging keeping all other parameters constant at their mean. Change in probability of tie $k \rightarrow j$ closing two-path $i \rightarrow k \rightarrow j$ with increasing difference in policy beliefs between i and j, depending on type of broker k. Mean posterior predicted probability (solid line) and 67 percent posterior density interval shown. Dotted lines indicate overall average between categories

between two organizations k and j, closing a two-path from an organization i to j, as political difference between i and j increases, while we vary actor type and forum participation categories.

We added a dotted line to these plots to show how a specific category compares to the average of all categories. The plots also give an estimate of uncertainty in our results, including uncertainty based on imputation of some policy belief variables (see Supporting Information for details).

The results illustrate the variance in the likelihood for brokerage among organizations. The main effect for the likelihood of cross-divide brokerage with increasing political difference is reliably negative in our models. However, our predicted probabilities for cross-divide brokerage, taking into account the whole model, show how broker organizations manage to overcome this.

When it comes to identifying most likely brokers, three overall findings stand out.

First, some organizations are likely above average to broker information in general, political divides non-withstanding. Scientific organizations stand out in this regard. They are likely

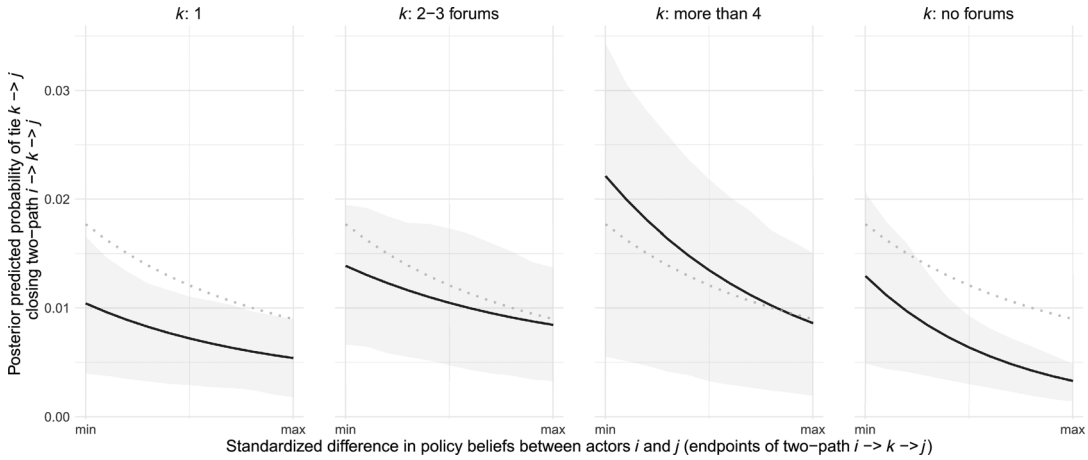

FIGURE 5 Impact of broker forum participation on cross-divide bridging keeping all other parameters constant at their mean. Type attribute fixed to tie between private sector actors. Change in probability of tie $k \rightarrow j$ closing two-path $i \rightarrow k \rightarrow j$ with increasing difference in policy beliefs between i and j, depending on forum participation of broker k. Mean posterior predicted probability (solid line) and 67 percent posterior density interval (gray area) shown. Dotted lines indicate overall average between categories

above average to play broker roles, compared to all other organizations (although the magnitude of the effect is more uncertain than for other organizational categories). Organizations who participate in many forums show a steep decline in their likelihood to broker as political differences increase. Still, they are at the minimum as likely as any other category of forum participation to broker across divides.

Second, the roles organizations assume in brokering information as political differences increase shows that some organizations may play specialized cross-divide broker roles. Comparing higher-level (state and federal) administration to interest groups illustrates this. Interest groups are as likely to broker between maximally similar others but show a steep decline (reducing their probability for brokerage between maximally dissimilar others by about two thirds) as differences increase. Higher-level administration organizations show a decline that is much less pronounced.

Third, some organizations are generally unlikely brokers. This applies especially to organization participating in no forums, private sector, and local administration actors.[7]

5 | DISCUSSION

The aggregate view of the information exchange network in Swiss water governance depicted in Figure 2 provides ample evidence for exchange of information across political divides in Swiss water governance. Exchange between clusters on aggregate is frequent. This is a reassuring sign from a normative standpoint, as especially the pro-ecology and the pro-development clusters represent two diametrically opposed clusters in Swiss water governance, a potential source of polarization and deadlock.

The results of exponential random graph modeling show a less reassuring picture with regard to the influence of policy stance dissimilarity on the likelihood of exchange between

organizations. Political division emerges as a likely factor reducing the likelihood of exchange, in line with results in previous studies of information exchange networks (Leifeld and Schneider 2012). Information exchange across political divides certainly takes place on aggregate, but it is encumbered by political differences on the individual level. As such, exchange is more likely to happen between the less ideologically extreme members of the network or within ideological cores of clusters.

This points toward the important role that cross-divide brokers can play in passing information from more extreme members of a cluster to outside actors. With regard to this brokerage function, our results show that brokerage in general is profoundly influenced by political division, but some organizations are more likely than others to play broker roles.

We find only limited support for Hypothesis H1a—higher-level administrative agencies are only slightly above average in their likelihood to broker across divides. However, besides science, they are the organizational category in our sample for which the likelihood for broker ties decreases the least with increasing political difference. In a nuanced way, this finding thus still supports ACF assumptions about the role administrative agencies play in brokering between coalitions (Leifeld, 2013). This is in line with arguments that playing such coordinating roles, if no other organizations assume them, can be both a reflection of how agencies understand their role in governance (Klijn & Koppenjan, 2000) and a way for them to exert indirect control (Fliervoet et al. 2015).

Our findings with regard to the role of scientific organizations contradict our Hypothesis H1b. Scientific organizations are the most likely cross-divide brokers in our sample. They have both a high probability in general of brokering information and for brokerage across divides. As such, scientific organizations play an extended role in brokering knowledge and are not mainly sources of information. We see this finding as a call for integrating the activity of scientific organizations more explicitly in policy network and ACF studies.

As expected, we find evidence for H1c, indicating that private sector actors are unlikely cross-divide brokers, which we ascribe to the transaction costs involved in brokering (Leifeld and Schneider 2012). We also find evidence for H1d. Interest groups play a role in information exchange much as envisioned in ACF theory by having a high likelihood to broker between similar others, thus most likely within coalitions (Ingold, 2011). Interest groups however show a low probability of brokering between dissimilar others. H1e is also supported by our results, although we cannot make a reliable statement about the cross-divide brokerage likelihood of municipalities, but rather that they are generally unlikely information exchange brokers at the scale we analyzed governance in this study. However, the dynamics we see play out in our large-scale analysis of Swiss water governance might play out similarly at the local microscale, with municipalities playing brokerage roles taken up by higher level agencies in our study. We see this as another argument for why more research is needed to unravel the multifaceted role of municipalities in governance (Mancilla García et al., 2019).

Organizations who participate in many (more than four) forums are especially likely to broker information between ideologically similar others. Together with organizations participating in two to three forums, they are also about twice as likely as all other categories of forum participation to be cross-divide brokers. This finding supports H2a and contradicts H2b, offering evidence for the benefits of forum participation on cross-divide brokerage. Forum participation further seems to have a moderating effect on organizations. The decrease in the likelihood for organizations to exchange information across divides is slightly less pronounced if they join a single forum, compared to if they are not participating in any forum. This moderating effect

increases again if they are part of two or three forums. We suggest that these results justify further research on policy forums as tools to overcome fragmentation in governance. Such research should also focus on discerning the point at which increased forum participation ceases to yield benefits, because the cross-divide brokerage benefits of organizations participating in many forums (beyond three) are not evident in our results.

6 | CONCLUSION

Swiss water governance is representative for other complex governance systems in containing a large and heterogeneous number of organizations who coalesce around a diverse set of interconnected and more or less divisive issues. This leads to a certain amount of polarization within the system. We can clearly observe clusters centered around pro-ecology and pro-(economic) development viewpoints.

We have set out the unencumbered exchange of technical information as a necessary condition for successful governance outcomes. In the generally well-functioning system of Swiss water governance, this is mostly the case. The fact that water governance in Switzerland happens within a framework of strong institutions and a country-specific setting of biophysical conditions clearly places limits on the amount of generalization we can draw for our case. However, even within this setting we still observe a strong effect of dissimilarity in political stances on the sharing of technical information between organizations. We would, therefore, expect this to be even more pronounced in situations where some problem pressures (such as drought in the case of water governance) are more pronounced and institutions are weaker. If ways to increase information sharing across political divides are important in our case, they are likely to be equally or even more important in other settings.

We suggest three main avenues for increasing information exchange across political divides.

First, the enhancement of institutional opportunity structures (Leifeld and Schneider 2012). Our results show a beneficial effect of policy forums in general for increasing exchange across divides. However, given this, we also find evidence questioning the effectiveness of actors participating in more than two or three forums for cross-divide brokerage. New or enlarged forums should thus focus primarily on including actors not yet present in many forums.

Forums do not need to be venues for debate on fundamental questions. Our results show that the effects of policy belief differences on information exchange do extend to the sharing of technical expertise. Forums focusing on exchange of technical information thus just as needed. Policy forums are not a panacea, but can definitively play a role in increasing exchange across political divides. Their effectiveness in doing so should therefore continue to be debated (Wagner & Ylä-Anttila, 2018).

Policymakers should also explore other avenues for institutional opportunity structures not addressed in this study. One possibility might lie in digital avenues such as open data platforms to spread information broadly at low cost. Another possibility lies in more traditional ways of organizing knowledge for organizations within a governance system, such as outlets of professional associations.

Second, the strength of relational and social opportunity structures (Leifeld and Schneider 2012) is probably not something to be overcome but rather to be acknowledged. In essence, some organizations, such as interest groups, will dis-proportionally engage with other organizations on their side of a political divide. This means that it can be more effective to

engage with brokers who can transmit information to like-minded organizations, rather than to reach out to large numbers of organizations directly.

Third, our results suggest that scientific organizations play a crucial role in brokering information across divides. To us, this result was unexpected. We hypothesized that scientific organization would play a stronger role as information providers than as brokers. Scientific organizations should take our results as a call to reflect more deeply on their actual role in complex governance systems and how this actual role is in line with their envisioned (and outwardly communicated) role. Policy network and ACF research should pay close attention not to overlook scientific institutions in analyses. Our results suggest that scientific organizations who assume an active role in governance networks are the most potent antidote to barriers in the flow of technical information across political divides.

We would hope to see replications of our analysis in different contexts, both in term of the substantive policy problems and geographically, and also using different methods to gauge the extent of political division and bridges between them. Also, in our opinion, more qualitative, smaller, and in-depth studies are needed that are more explicit about the actual content of technical information that is exchanged in cases of bridging across political divides and the exact circumstances within which this is done. This should not only come from the scientific community, but also professionals working in various governance fields.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

ENDNOTES

[1] Cantons are the constituent states within the federal system of Switzerland. We refer to cantons as states hereafter.

[2] We use the term regional for any region that is sub-cantonal, but spanning municipal borders.

[3] "Fachwissen" in German.

[4] "Grundlagenwissen" in German.

[5] Containing the options "strongly disagree," "disagree,""agree," "strongly agree."

[6] The fields of expertise included "biology," "chemistry," "communication," "engineering," "geology," "law," "lobbying," "management," "mobilization," and "research." Respondents were given the chance to select multiple areas of expertise.

[7] We did not model an interaction with local administration actors explicitly, because they provided so few broker ties that making statements about patterns in their brokerage activity seemed a moot point. They are simply unlikely brokers in general at the level of analysis we take in this study.

DATA AVAILABILITY STATEMENT

An anonymized version of the data set we used in this article, as well as code enabling the replication of our analysis, is provided in an open online repository: https://doi.org/10.5281/zenodo.4626528.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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APPENDIX: Clustering

TABLE A1 Summary of median values per cluster regarding agreement or disagreement with statements regarding salient issues in Swiss water governance (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree)

Cluster	Fertilizer input into streams should be reduced	Landscape protection more important than hydropower	Agriculture more important than revitalization	Support subsidies for large hydropower plants	Small-scale hydropower has great potential	Support regionalization of water supply	Municipal input into hydropower project planning important	Flood protection is too encumbered by nature protection laws
1 (Pro-ecology)	4	3	1	2	1	4	2	1
2 (Neutral/ administrative)	4	3	2	3	2	3	3	2
3 (Pro-development)	3	2	3	3	3	3	3	3

Causal model (DAG)

We rely on a directed acyclic graph (DAG) based approach to select covariates for modeling. The main information the graph provided for modeling was that failure to adjust for expertise similarity or issue similarity biases estimation of the direct causal effect of forum participation by creating a back-door path via forum participation similarity. Further, the graph shows that adjusting for the total set of variables included in the DAG does not create additional bias via inclusion of covariates.

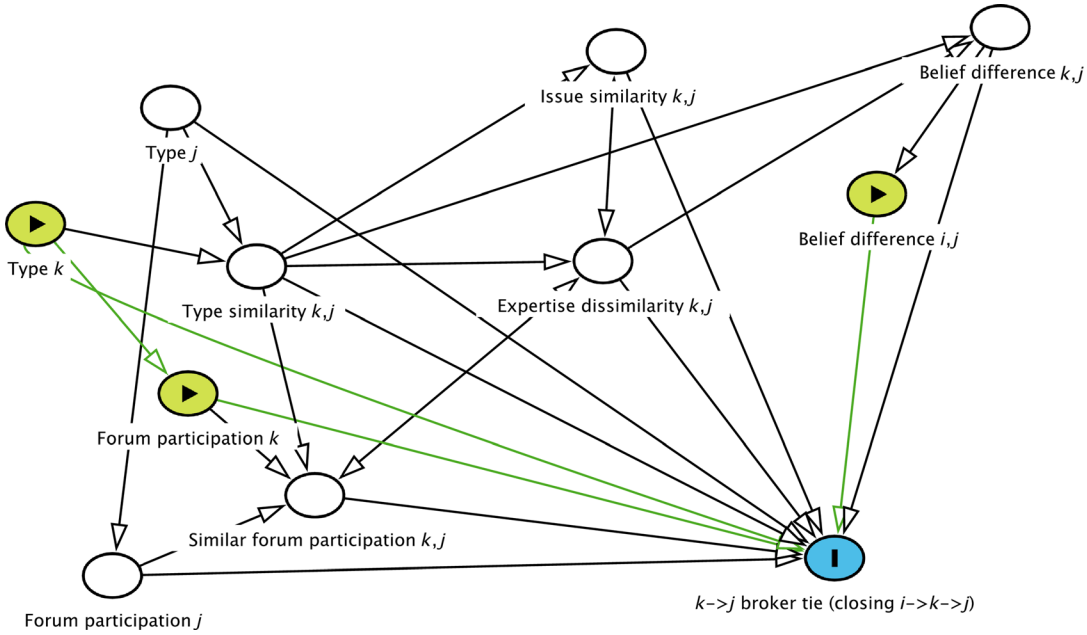

FIGURE A1 Directed acyclic graph used in covariate selection. Green nodes indicate exposure variables (for which hypotheses were formulated), the blue node indicates the outcome (a $k \rightarrow j$ broker tie). Created with dagitty (Textor et al., 2016)

Posterior distribution of BERGM model coefficients

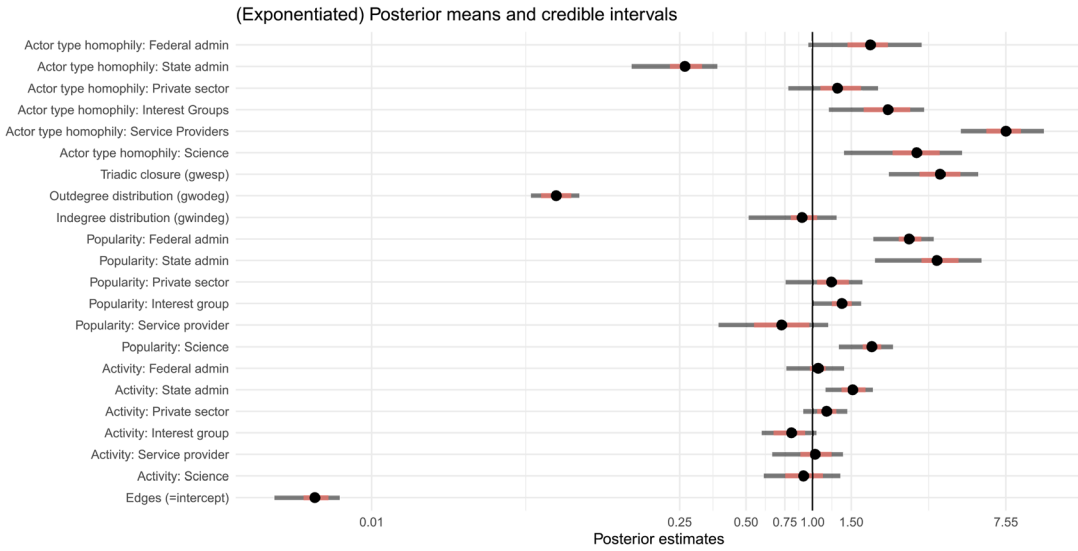

FIGURE A2 Posterior distribution of coefficients of the first (network of survey respondents and nonrespondents) Bayesian exponential random graph model of technical information exchange in Swiss water governance. Posterior coefficient distributions are reported as odds ratios with credible intervals and plotted on a log-scale. Red lines indicate 50% credible intervals, gray lines indicate 95% credible intervals. These distributions were later used as priors for the second model reported in Figure A3

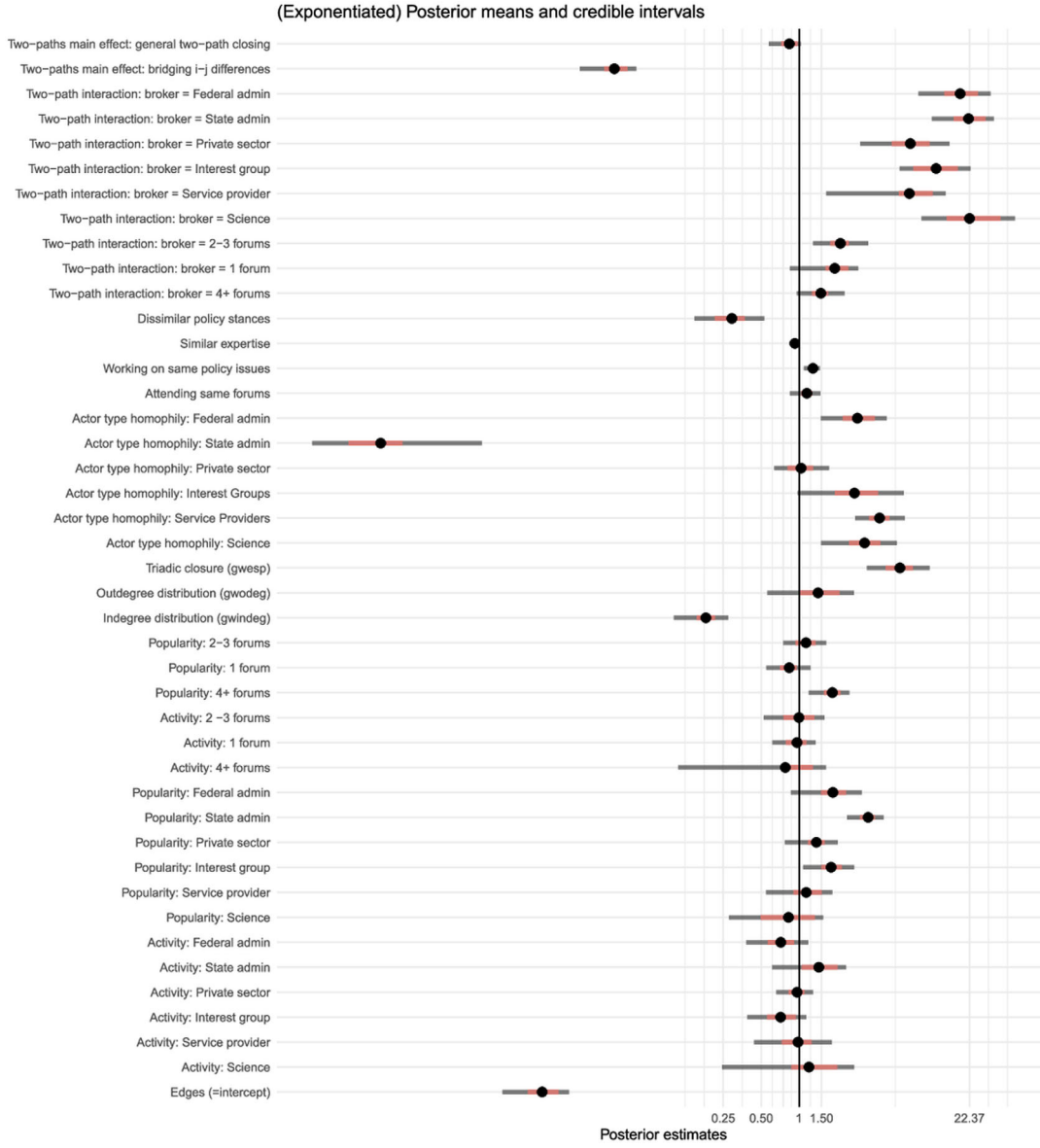

FIGURE A3 Posterior distribution of coefficients of the second (only survey respondents) Bayesian exponential random graph model of technical information exchange in Swiss water governance. Posterior coefficient distributions are reported as odds ratios with credible intervals and plotted on a log-scale. Red lines indicate 50% credible intervals, gray lines indicate 95% credible intervals