Received: 26 October 2022 | Revised: 3 May 2023 | Accepted: 20 June 2023
DOI: 10.1111/psj.12515

ORIGINAL ARTICLE

PSO PSJ POLICY STUDIES JOURNAL

Who is satisfied with their inclusion in polycentric sustainability governance? Networks, power, and procedural justice in Swiss wetlands

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Funding information
DIZH, Digitalisierungsinitiative der Zürcher Hochschulen; Schweizerischer Nationalfonds zur Förderung der Wissenschaftlichen Forschung, Grant/Award Number: 172665

Abstract
Sustainability governance in polycentric systems needs to ensure both effectiveness and procedural justice. Effectiveness and procedural justice are intricately linked to power dynamics in governance. To assess polycentric sustainability governance, understanding different types, sources, and effects of power is key. Here, we investigate network-derived bonding and bridging social capital of actors as specific sources of power in polycentric sustainability governance. We ask two questions: How does bridging and bonding social capital translate into power? And: How is the power associated with satisfaction with inclusion? We relate levels of bonding and bridging social capital to power and satisfaction with inclusion in governance processes for 299 actors in 10 cases of Swiss wetlands governance. Using a Bayesian multi-level regression model, we find that especially bonding social capital is a source of power for actors. Further, network-derived power but also nonnetwork-derived power by design translates into satisfaction with inclusion. Research and practice of sustainability governance need to be careful to account for power in nuanced ways, acknowledging its sources and relation to procedural justice.

KEYWORDS
governance, networks, polycentricity, procedural justice, sustainability

INTRODUCTION

One of the key challenges for humanity in the 21st century is effective and inclusive sustainability governance (Burch et al., 2019). Sustainability governance includes all action on common affairs of any collectivity (Clark & Harley, 2020) on issues related to sustainability-related outcomes. Examples range from natural resource governance to urban mobility transformations or energy provision.

Sustainability governance often takes place within polycentric governance systems. In a polycentric governance system, governance activity is distributed across the system (Ostrom, 2010). A key contribution of the policy studies literature to sustainability governance has been to develop an understanding of structures and processes in polycentric governance systems and how effective these are in impacting sustainability-related outcomes (Lubell & Morrison, 2021). Next to evaluating effectiveness, research on sustainability governance is also paying increasing attention to questions of inclusion and procedural justice in polycentric sustainability governance (Okereke, 2018; York & Yazar, 2022).

In this article, we follow recent calls for unraveling the impact and function of power dynamics within polycentric governance systems (Berardo & Lubell, 2019; Morrison et al., 2019) in relation to inclusion and procedural justice. A key entrance point to study questions of inclusion is the individual actors who make up a polycentric governance system (Scott & Thomas, 2017). These actors are embedded within organizational networks, including actors from all societal sectors (Bodin et al., 2019; Rhodes, 1996; Scott & Ulibarri, 2019) within an ecology of games, a larger environment of interconnected issues, venues, and institutions (Lubell, 2013).

Our specific contribution to this article is to disentangle interrelations between *bonding and bridging social capital*, *power*, and *inclusion* of individual actors in polycentric sustainability governance. The network position of actors has often been conceptualized as a source of power for actors that exist next to openly authoritative sources of power (Mancilla García & Bodin, 2019). In the context of the nuanced typology of power in polycentric governance systems developed by Morrison et al. (2019), we propose that bridging and bonding social capital derived from the position of an actor in a governance network (Berardo, 2014) is relevant as a source of pragmatic and framing power.

More generally, the proposition that networks or relations (Lubell & Morrison, 2021) somehow shape governance on both the individual and system level is at the heart of why the literature on polycentric governance even cares about networks in the first place. The proposition of a link between network-derived social capital and power for individual actors has, however, seldom been put into the context of a nuanced typology of power in polycentric governance and empirical tests for such a proposition are rare. We, therefore, see value in asking a first, fundamental question on the connection between network-derived social capital and power:

> Research Question 1. How does bridging and bonding social capital translate into power in polycentric governance systems?

We recognize that networks are both a source but also a consequence of power. Governance networks are shaped by power by design (Héritier & Lehmkuhl, 2008), for example, because governmental actors with formal authority are preferred collaboration targets (Leifeld & Schneider, 2012). However, networks are not exclusively shaped by power by design. Especially in highly polycentric systems, governance networks can open up additional avenues to attain network embedding derived power for actors both high and low in power by design (Mancilla García & Bodin, 2019).

When it comes to questions of inclusion and procedural justice, understanding sources of power in polycentric governance is only a first step. The realization of actors' preferences fornot fully determined by power and different types of power may not translate into inclusion in the same way. In order to advance our understanding of how power creates winners and losers (Morrison et al., 2019; Scott & Thomas, 2017) in polycentric sustainability governance, we therefore go one step further and ask:

> Research Question 2. How does network-derived power influence satisfaction with inclusion in polycentric sustainability governance, compared to other sources of power?

In a rare multi-case study of governance networks and perceptions on the actor level, we relate individual-level satisfaction with inclusion in the governance process and measurements of power to governance network embedding for 299 organizational actors across 10 cases of Swiss wetlands governance in a Bayesian multi-level, multivariate regression model.

Wetlands are prime examples of complex, polycentric sustainability governance settings. They are places where multiple, at times competing societal demands on a natural resource concentrate in space, including issues as diverse as flood protection, recreational use, hydropower production, or biodiversity. Our governance networks include state, civil society, and private sector actors engaging with these issues related to a given wetland.

THEORY

Inclusion and effectiveness in polycentric sustainability governance

At this point in time, there is hardly any discussion of sustainability governance, which does not refer to the normative ideal that governance for sustainability must combine both inclusion and effectiveness. This is evident in high-level agenda-setting activities in governance frameworks such as the United Nations 2030 Sustainable Development Goals (United Nations General Assembly, 2015), reports by large funding agencies like the American National Science Foundation (National Academies of Sciences, Engineering, and Medicine, 2022) or academic literature reviews (Burch et al., 2019; Clark & Harley, 2020).

Accordingly, questions of effectiveness and inclusion have been key topics of investigation in a polycentric governance systems specifically. Actors in polycentric governance systems interact with each other across multiple decision-making venues (Lubell, 2013) characterized by a multitude of formal and informal institutional rules. Lubell and Morrison (2021) recently introduced the concept of *institutional navigation* to study polycentric sustainability governance from the viewpoint of individual actors. Institutional navigation emphasizes individual agency. It provides an overarching framework under which to study how actors in polycentric governance system act and interact in order to achieve individual and collective goals.

Institutional navigation happens within complex systems composed of a large sum of interacting parts (Lubell, 2013) characterized by profound uncertainty (Burch et al., 2019). It is not surprising that Lubell and Morrison (2021, p. 664) speak of an "art" that there is to such navigation. Many actors in polycentric governance systems engage seemingly effortlessly in institutional navigation, much as artists, we admire practicing their craft. Institutional navigation entails that actors take a large number of conscious and unconscious, recurring decisions on how they engage in polycentric governance systems. Key among these decisions are which issues to tackle and which stance to take regarding them; which venues for policy-making to join (Angst et al., 2021); and which actors to interact with and in which fashion (Scott & Ulibarri, 2019). The outcome of these choices determines how effective an actor can be in reaching their goals. The combined choices of all actors in the governance system shape the system and produce overall collective outcomes. The institutional navigation framework challenges the existing literature on sustainability governance to develop an understanding of effective institutional navigation. In our understanding, an actor is ultimately effective in navigating a polycentric governance system when they achieve their individual goals according to their specific organizational interests, mandates, and logic. However, as Lubell and Morrison (2021) acknowledge, not all actors have access to the same portfolio of strategies to employ to achieve their goals. This brings questions of inclusion and procedural justice to the forefront, both as a subject of study as fundamental normative goals of sustainability governance (Okereke, 2018), as well as in relation to effectiveness.

Analytically, inclusion and power in institutional navigation can be approached from an individual and a collective perspective. On the individual level, the study of inclusion in institutional navigation covers the strategies actors can employ and the constraints they face when it comes to both attaining power and increasing their likelihood of achieving their own preferences for inclusion in polycentric governance systems. On the collective level, the interest with regard to inclusion lies in systemic conditions and common patterns in actor behavior that are associated with an increased likelihood for the realization of procedural justice as a systemic property. From this perspective, questions of trade-offs between inclusion and effectiveness might also become more apparent (Morrison et al., 2019).

There is an important distinction between individual and collective perspectives in terms of the normative orientation of research questions related to institutional navigation. Questions of collectively effective and inclusive navigation are very much tied to normative goals of a governance system that manages to produce sustainable outcomes, including procedural justice, and how individual actors can contribute to this. Inclusion and effectiveness on the individual level, however, are in principle only tied to how actors achieve their own, specific goals. These may include goals seen as producing unsustainable outcomes by a majority of stakeholders or scientific consensus. In our understanding, research on institutional navigation in polycentric sustainability governance must study both levels in order to gain an understanding of institutional navigation on a general level. In other words, the study of determinants and the distribution of inclusion on the individual actor level is a crucial precondition to discussions of procedural justice but procedural justice can ultimately not be resolved on the individual level.

Power and its relation to inclusion in polycentric governance systems

Power is one of the richest concepts in social science and the nuances to which it has been explored are hard to do justice in an encompassing manner. Here, we follow Morrison et al. (2019), who offer a helpful typology of power specifically in the context of polycentric governance. They broadly define power as "the uneven capacity of different actors to influence the goals, process, and outcomes of polycentric governance" (Morrison et al., 2019, p. 2) and distinguish between three main types of power. First, *power by design* is authoritative power, combining power and legitimacy, which is "written, legislated and visible" (Morrison et al., 2019, p. 3). In governance networks, state actors with formal competencies to enforce existing legislation are an example of actors we usually expect to hold such power (Angst et al., 2018). Second, *pragmatic power* is tied to the discretion actors enjoy in the application or non-application of existing formal or informal rules in governance. For example, local organizational actors, such as municipalities, in governance networks often need to translate higher-level policies in cooperation with other local actors into action and can shape how a policy plays out on the ground decisively (Mancilla García et al., 2019). Third, *framing power* is a softer, less visible type of power, related to the ideological framing of governance issues and related agendas by actors. For example, civil society organizations might exercise framing power by engaging in campaigns to portray certain social practices, like driving cars or supporting coal power plants, as literally dirty.

In polycentric governance systems, power asymmetries between actors for different types of power are the norm. Power asymmetries often lead to differences in inclusion on the actor level, for example, when actors are excluded from crucial formal and informal decision-making venues or forums (Mancilla García & Bodin, 2019; Morrison et al., 2019).

A key theoretical framework to study the structural signatures of power and inclusion compatible with the actor-centered focus of the institutional navigation framework has been the ecology of games (EoG) framework (Lubell, 2013). Taking stock in 2019, (Berardo & Lubell, 2019, p. 18) stressed how some EoG research (Mancilla García & Bodin, 2019; Mewhirter et al., 2018; Scott & Thomas, 2017) had started to illustrate how power imbalances can lead to unequal resource access in polycentric governance systems, which may perpetuate or deepen existing power asymmetries. On the system level, this may contribute to sub-optimal outcomes.

It is worth noting that Berardo and Lubell (2019, p. 19) approach inclusion from an instrumental perspective in this context, calling mainly for further EoG studies that illuminate the causal chain running from power imbalances over system fragmentation to reduced capacity for collective problem-solving. Properties of inclusion are not explicitly approached as nonnegotiable normative goals in their own right, as they commonly are in procedural justice approaches. Still, even in cases where properties of inclusion are seen as goals in their own right, power asymmetries need to be approached in a nuanced way and are not per se undesirable. Traditionally underrepresented actors may also make use of power asymmetries as alternative sources of power (Morrison et al., 2019) within complex ecologies of games. In the case of the Paraíba do Sul river basin committee in Brazil, Mancilla García and Bodin (2019) find that participation in a larger number of policy forums is related to increased perceived influence for a diverse number of actors beyond traditionally powerful actors with power by design.

Network-derived bridging and bonding social capital as sources of actor power

We investigate two specific, but key actor-level features of institutional navigation, which are the levels of network-derived bonding and bridging social capital as sources of power, and their relation with inclusion. We, therefore, focus on the relationships that actors build with other actors in governance networks (Bodin & Crona, 2009; Scott & Ulibarri, 2019). Put differently, we ask how two specific features of the governance network positions of organizational actors translate into inclusion.

We posit that network-derived power based on bridging and bonding social capital is a source of pragmatic and framing power in polycentric governance systems and is a complement to power sourced in other ways. We suggest that both bridging and bonding social capital are sources of pragmatic and framing power (summarized in Table 1). Both pragmatic and framing power can, however, also originate from other sources. Power by design, by definition, is not sourced from network embedding.

The differentiation between bridging and bonding ties in social networks has a long tradition in social network analysis in general (Burt, 2000) and in environmental governance networks specifically (Angst et al., 2018; Berardo, 2014; Bodin & Crona, 2009; Scott & Thomas, 2017). They describe two conceptually opposite ways in which individual actors in a social network can derive advantages from the way they are embedded in a network. We test a number of hypotheses about the influence of bridging and bonding along an assumed process running from network embedding as a source of power to its translation into inclusion. All hypotheses introduced in detail below are summarized in Table 2.

Bridging ties, akin to the "weak ties" made famous in Granovetter (1973) are ties that "bridge" different parts of a network. An actor with many bridging ties can use these to assume a broker role

TABLE 1 Bridging and bonding social capital as sources of power (with examples in parentheses) in polycentric governance systems compared with power sourced outside the network by type (Morrison et al., 2019) of power.

	Source of power		
	Network-derived		
Type of power	Bridging social capital	Bonding social capital	Outside network
By design	No	No	Yes (formal authority)
Pragmatic	Yes (control over information flow)	Yes (risk reduction in discretionary implementation through transitivity)	Yes (discretion in implementation)
Framing	Yes (information brokerage in shadow networks)	Yes (trusted information source)	Yes (control of one-to-many information distribution systems)

TABLE 2 Overview of hypotheses and associated processes developed and tested.

Hypothesis	Process tested
1	Bridging → Power
2	Bridging → Power → Inclusion
3	Bonding → Power
4	Bonding → Power → Inclusion
5	Bridging × bonding → Power

(Everett & Valente, 2016; Gould & Fernandez, 1989; Granovetter, 1973). Actors in brokerage positions are often hypothesized to gain an advantage in governance networks by being able to control information flows (Jasny & Lubell, 2015) and strategically influence policy processes (Ingold & Varone, 2012). As such, bridging social capital is an avenue for actors to pragmatic power. Bridging ties are also a likely avenue for actors to gain framing power, for example, by brokering information in informal shadow networks (York & Yazar, 2022). Empirical tests relating bridging or brokerage positions to actor-level outcomes in governance networks have however been relatively rare (Scott & Thomas, 2017). We therefore see value in testing the following two hypotheses, related to our overall research questions. The first bridging hypothesis tests the assumed link between bridging ties and increases in the two specific types of power we link to network embedding:

> **Hypothesis 1.** Higher levels of bridging ties are associated with increased network-derived power of an actor.

The second bridging hypothesis is set up to test the degree to which power sourced from bridging ties is translated into inclusion.

> **Hypothesis 2.** Higher levels of bridging ties are translated via increased network-derived power into increased satisfaction with inclusion in the governance process.

Bonding ties describe relations of trust and reciprocity within cohesive subgroups. The literature on civic engagement has long placed an emphasis on bonding social capital derived from bonding ties (Putnam et al., 1993). Bonding social capital, in its relation to trust, is therefore likely to be a source of framing power. Actors with high-bonding social capital are likely to be trusted information sources, enabling them to frame governance issues more authoritatively within their subgroups.

As a source of pragmatic power, in governance networks, the importance of bonding ties has been emphasized for situations where actors need to rely on the cooperation of others to solve governance problems but there is a high risk of noncooperation or defection by other actors. The potential for gaining control in these situations through transitive structures associated with bonding ties has prominently been hypothesized in the so-called risk hypothesis as especially important in such contexts (Berardo & Scholz, 2010). Conversely, the risk hypothesis suggests that in situations of low-risk or long-established collaborations, bridging ties gain prominence. There have been empirical results broadly supporting the risk hypothesis in different contexts (McAllister et al., 2015; Olivier & Berardo, 2021), although it is probably fair to say that many empirical settings are characterized by degrees of mixtures of high risk and low risk, as well as variance in bridging and bonding ties within networks. In terms of the role that bonding social capital may play as a source of actor power, the theoretical framework drawn up by the risk hypothesis would thus suggest that bonding social capital would be sought after by actors in high-risk situations.

Similar to the bonding hypotheses, we draw up hypotheses along the causal chain running from network embedding over power to inclusion. The first bonding hypothesis tests the assumed link between bonding ties and increases in the two specific types of power we link to network embedding:

> **Hypothesis 3.** Higher levels of bonding ties are associated with increased network-derived power of an actor.

The second bonding hypothesis is set up to test the degree to which power sourced from bonding ties is translated into inclusion.

> **Hypothesis 4.** Higher levels of bonding ties are translated via increased network-derived power into increased satisfaction with inclusion in the governance process.

Bridging and bonding ties are conceptually opposite, but they are not mutually exclusive. The ego network of an actor can contain both bonding and bridging ties. The two types of ties may also interact. Actors combining both bridging and bonding have analogies in network science more broadly, for example, in the concept of network hubs or super generalists in ecological networks (Olesen et al., 2007). Burt (2000) made the argument that social capital is indeed created by bridging ties that span structural holes but that it is local closure and bonding ties that make it possible to leverage this capital. Given this, we would expect an interaction effect between bridging and bonding. Actors combining one type of social capital with the other (without necessarily excelling in each) should be able to leverage it more effectively:

> **Hypothesis 5.** Increasing levels of bridging ties increase the positive association of bonding ties with network-derived power of an actor and vice versa.

Networks and network-derived social capital as a consequence actor power

Both theories used to understand governance networks as a concept of governance and their actual manifestations are often strongly tied to notions of hierarchy (Wachhaus, 2011). As such, processes in governance networks often take place under a "shadow of hierarchy" (Héritier & Lehmkuhl, 2008). For example, strong governmental organizations have been shown to take key positions in network governance approaches supposedly marking a shift from top-down control to collaborative governance (Fliervoet et al., 2016), resource-rich actors participate above average in key venues of polycentric governance systems, such as policy forums (Angst et al., 2021), and the possibility of hierarchical interventions by higher-level actor shapes collaborative government arrangements (Zhou & Dai, 2021).

The recognition that networks are shaped by power is crucially important for analytical reasons. To analyze networks as a source of power as well as its influence on inclusion, it is necessary to adjust for power by design, given its influence on the shape of networks. Power by design is a clear case of confounding when analyzing the impact of network-derived social capital on inclusion and power. Without taking into account power by design when analyzing the impact of network-derived social capital, we cannot be sure if an association between network-derived social capital and power or inclusion is actually a case of eg. high levels of power by design of an actor shaping their network and in turn their potential for realizing their preferences for inclusion.

METHODS

Cases

We selected 10 cases of Swiss wetlands governance (see Figure 1) based on a four-step approach to ensure both comparability of governance systems within our sample and representativeness of the sample at the country level. Each case study includes one or more wetlands listed in the inventory for alluvial wetlands of national importance,[1] which lists 326 areas in Switzerland that have outstanding importance for the protection of wetland systems.

First, we excluded wetlands located in remote areas such as the high alpine regions and only kept wetlands along rivers and lakes. Excluding wetlands in high alpine regions makes the remaining wetlands more comparable regarding relevant social, economic, and ecological management issues. Second, we grouped single wetlands into larger wetland systems based on their presence in river catchment areas and spatial proximity to other wetlands. Therefore, multiple separate wetland systems within one catchment area can exist. However, purely geographic case boundaries do not adequately cover the multi-dimensional nature of governance issues in wetlands (Moss, 2012). Therefore, we also included socioeconomic aspects (adjacent farming or upstream hydropower plants) to include further

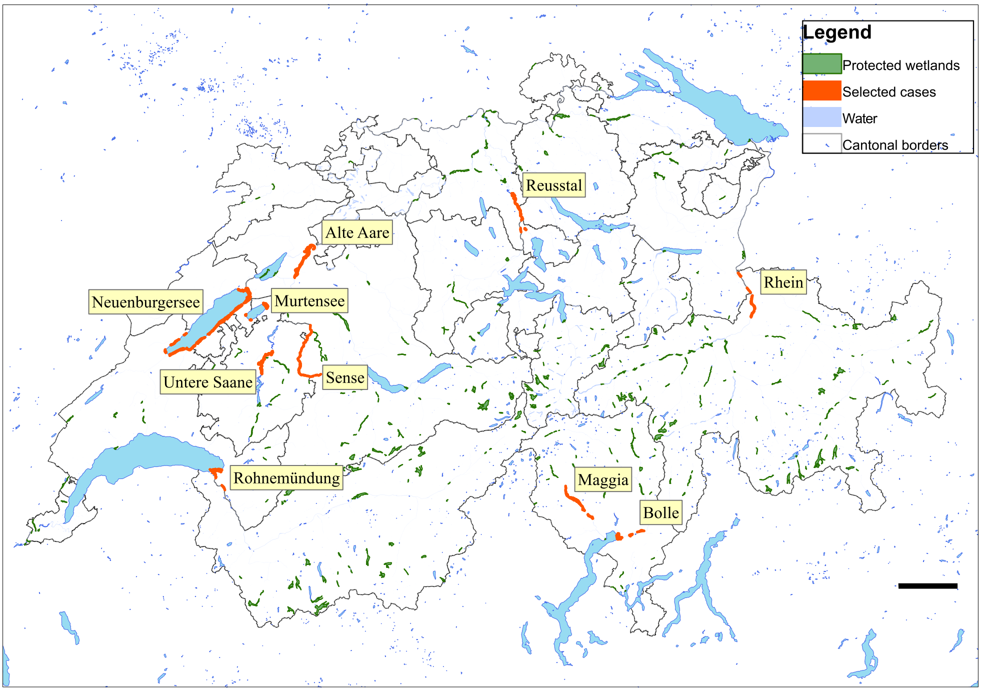

FIGURE 1 Overview over cases included in analysis across Switzerland.

surrounding areas that form one functional unit for the governance of the respective wetlands. Third, the cases were selected to cover three of the four linguistic regions of Switzerland (German, French, and Italian) and different cantons across Switzerland to account for geographical and sociocultural diversity. Fourth, while half the cases are located entirely within one canton's territory (cantons are the constituent states and substates of Switzerland), the other half of cases cut across cantonal borders and are governed by multiple cantons. This reflects an important feature of governance in a federalist systems such as Switzerland.

From the wetlands that fulfilled these four criteria, we selected 10 cases that are included in the analysis of this paper. Within those 10 cases, we sent out online surveys (in German, French, or Italian) to 521 actors that were identified to be relevant for wetlands governance through expert interviews and document analysis. 349 actors filled out the survey leading to a response rate of 67%. Respondents per case ranged from a min = 26 to max = 52 per case with a median of 32, which is broadly in line with many studies of other small- to medium-sized natural resource governance networks (Bodin et al., 2019).

Variables and measurement

Distributions and pairwise relations among all variables used in modeling are shown in Figure A1 in the appendix. Two variables we utilize contained missing values. First, 14.3% of respondents ($n = 50$) did not provide an answer with regard to satisfaction with inclusion in the governance process (see Section Satisfaction with inclusion in the governance process). Additionally, 23.4% did either not choose a top priority issue or not assess the status of the issue (see Section Priority issue status). We excluded these respondents from the analysis (row-wise deletion) based on computational efficiency considerations compared with imputation after exploring the sensitivity of results to imputation.

Satisfaction with inclusion in the governance process

We use a straight-forward survey item to measure satisfaction with inclusion in the governance process for individual actors. Actors were asked on a four-point Likert scale whether they strongly agreed, agreed, disagreed or strongly disagreed with the statement "my organization is involved in decisions that have an impact on [name of the case] to a satisfactory degree" (exact German wording: "Stimmen Sie den folgenden Aussagen zu? a) Meine Organisation ist in Entscheidungen, die die [Name Fallstudie] betreffen, genügend einbezogen").

Bonding and bridging

We collected fine-grained data of collaboration networks among actors involved in wetlands governance in each case. This network data form the basis for our measurements of network-derived bonding and bridging social capital of individual actors.

We asked survey respondents to choose from a roster of all actors per case the actors they collaborated with in wetland governance. Given this initial list of general collaboration, actors were then asked to qualify their relationships with their collaboration partners in two dimensions. They were asked in which specific issues (see section on priority issue status) the collaboration occurred, as well as whether the collaboration was positive (constructive), negative (difficult), or both. For the computation of bridging and bonding ties per actor, we symmetrized all networks using a weak criterion, therefore, establishing an undirected collaboration tie for every dyad if at least one of the actors in the dyad indicated that the actors collaborated. We chose to do so primarily because it enabled us to take into account collaboration ties to nonrespondents, leading to a more complete representation of the overall network structure in place, which is crucial for a valid computation of network metrics depending on the shape of the entire network. Network size including nonrespondents in this way ranged from min = 44 to max = 92 with a median of 64. All collaboration networks are plotted in Figure A2 in the appendix. As an additional sensitivity check (see online appendix), we also re-ran all our models with a strong symmetrization procedure (establishing a tie only if both nodes indicated a collaboration, effectively discarding nonrespondents), which does not influence the overall tendencies in results.

To measure bonding social capital per actor, we use the number of closed triads an actor is involved in their nonnegative, undirected collaboration network. A closed triad is a network constellation where three actors are all connected to each other. For an individual actor, a count of closed triads indicates the number of times their network contacts are themselves connected. This so-called transitive closure is a often used measurement for local density and bonding ties (Berardo & Scholz, 2010). For an individual actor, it indicates that the actor is part of a closely connected collaboration network of other actors with whom they have productive relations. In the online appendix, we report a sensitivity check measuring transitive closure including all collaboration ties, which does not result in a notable change in results.

To measure bridging social capital per actor, we rely on a local measurement of betweenness centrality in each actor's collaboration network. Betweenness centrality is a classic measure of bridging potential for an actor and measures the amount to which an actor exclusively lies between other actors (Everett & Valente, 2016). Betweenness centrality for an actor is the sum of the fraction of shortest paths between every other pair of actors in the network that the actor lies on. As such, actors with high betweenness centrality provide efficient connections in a network, putting them in likely brokerage positions. We calculate betweenness for each actor based on their so-called ego network of order two (thus based on a network subset including all network contacts and their connections up to two contacts removed—collaborators of collaborators), as we argue that brokerage loses a lot of substantive meaning for connections that extend further (Angst et al., 2018). We used both positive and negative collaboration ties to construct our measure of bridging to reflect the fact that brokerage positions might also involve providing bridges among actors with conflicting views or in difficult collaborative settings. In the online appendix, we report a sensitivity check expanding the ego network definition to include an order of three, which does not result in a notable change in results.

We normalize bonding and bridging by case. This accounts for the fact that absolute numbers of triad counts and local betweenness are not directly comparable between cases as they may depend on the size and properties of the collaboration networks in each case. As essentially both measures are counts and strictly nonnegative, we also log-transform them, as the log transformation in this case ensures a more natural scaling.

Ascribed general power

We measured an actor's general power over the governance process in each case by relying on the assessment of all other surveyed actors in the case. As such, we use an aggregate of dyadic influence attributions as a proxy (Ingold & Leifeld, 2014) for a generalized, relatively diffuse assessment of power.

Actors were asked to indicate for all other actors in the case (including actors they did not collaborate with) whether they considered them especially important for goal achievement in their priority governance issue (see below). We used the number of times an actor was indicated as influential by others to generate an individual score for ascribed power for each actor.

This diffuse measure of power potentially contains assessment of framing power, pragmatic power, and power by design of actors. As such, put into relation with network embedding and inclusion, the measure on its own does not make it possible to make nuanced statements about how specific types of power are derived from network embedding nor how they influence inclusion. However, as we will outline in the causal model section, we will be able to approximate such statements by adjusting for a proxy for power by design.

Actor type as a proxy for power for design

Previous research on governance networks has shown repeatedly that actors with different institutional standing and on different jurisdictional levels face different opportunities and constraints in their ability to influence outcomes and processes of governance (Fliervoet et al., 2016; Héritier & Lehmkuhl, 2008; Kininmonth et al., 2015). In Swiss water governance contexts, especially higher-level state actors on the cantonal and federal levels are a key type of actor with generally high power by design (Angst et al., 2018), followed by local municipalities whose formal competencies in wetlands governance vary by issue area.

Given this, we included actor type as an actor attribute manually coded by the researchers involved in data gathering, combining the jurisdictional level and societal sector of an actor to approximate power by design of an actor. This leads to four main types of actors relevant for wetlands governance in our case. In order of decreasing average power by design, these were higher-level governmental agencies, local-level municipalities, local and higher-level nongovernmental organizations, as well as an "other" category including mostly local companies and service providers.

Priority issue status

It is likely that satisfaction with inclusion in the governance process varies by case, as some cases of wetlands governance, for example, face more pronounced levels of conflicts such as use conflicts. Beyond this, we suggest that satisfaction also varies across groups of actors based on the status of specific governance issues actors are interested in.

Natural resource governance systems, such as the wetlands we study, usually revolve around multiple, at times competing issues (Hedlund et al., 2021). Across all ten cases, we identified a total of 89 wetlands governance issues through exploratory expert interviews with 2–3 experts per case. Over a series of iterative coding rounds, these issues were grouped into 12 overarching wetlands governance issues, which formed the basis of the actor surveys in each case. Not all issues were relevant for each case, given bio-physical differences and differing usage patterns. For example, forestry and timber harvesting were only relevant in one specific case. Thus, not all issues appeared in every survey. Expert interviews were conducted several weeks before survey administration in each case. Experts were chosen to be representative of a wide variety of viewpoints in wetlands management and depending on the cases included state actors, private actors and NGOs.

Actors are likely to be more satisfied with their inclusion if they deem the status of issues they most care about to be positive. Many actors are specifically involved in wetlands governance in order to champion a specific issue and other issues are of secondary interest to them or do not concern them. This is especially relevant for the organizational actors we study, as many organizations, such as energy production companies, flood prevention agencies or local nature protection groups have a relatively well-defined single issue focus and follow associated organizational logics.

We focus on the top priority goals for each actor based on a survey question, where respondents were asked to rate how important issues were to them in a survey item that asked them to rank issues in order based on the question: "which goals in [case study name] are most important to your organization?" (exact German wording: "Welche Ziele an der [Name Fallstudie] sind für Ihre Organisation besonders wichtig?").

In order to assess how actors evaluate the status of their top priority issue we utilize information form a survey item that asked respondents to indicate how they rated the current state of goal achievement for each wetlands governance issue present in a given case on a three point scale ranging from "goal achieved," over "neutral" to "goal not achieved" (exact German wording: "Unten sehen Sie mögliche Ziele für die Auengebiete an der [Name Fallstudie]. Wie gut werden diese Ziele Ihrer Meinung nach erreicht?")

Causal model

We formalize the causal assumptions informing our modeling introduced in our theoretical framework in a directed acyclic graph (DAG) (Pearl, 2009; Shrier & Platt, 2008; Tennant et al., 2021). The DAG serves two purposes. First, to guide our model building by highlighting variables that need to be adjusted for confounding and second, to expose our assumptions to scrutiny. Figure 2, produced using `dagitty` (Textor et al., 2016), displays this graphically. To simplify the illustration, bridging and bonding are subsumed under network embedding.

First, the DAG formalizes the two-step approach we take in our research design to disentangle the relationship among network-derived social capital, power and inclusion. The causal path running from network-derived social capital to inclusion runs via power, illustrating that we need to model power both as an outcome (of network embedding) and a predictor (for inclusion).

Second, a crucial assumption we introduced in our theoretical framework exposed in the DAG is that power by design can only originate outside networks. Further, network-derived social capital can be a consequence of power by design. As such, to isolate the total effect of bridging and bonding social capital for both power and on inclusion, we need to adjust for power by design, which we do by adjusting for actor type as a proxy.

Third, we assume that the priority issue of an actor has an effect on their satisfaction with inclusion in the governance process, given that in some issues, actors active in them have a higher (or lower) likelihood of being satisfied on average as the status of the issue starts from higher (or lower) baseline. One example for this are long-established, strictly regulated flood protection measures, where we generally expect higher levels of satisfaction than in more contested issues such as biodiversity protection. The same applies for the distribution of satisfaction with inclusion in the governance process across cases

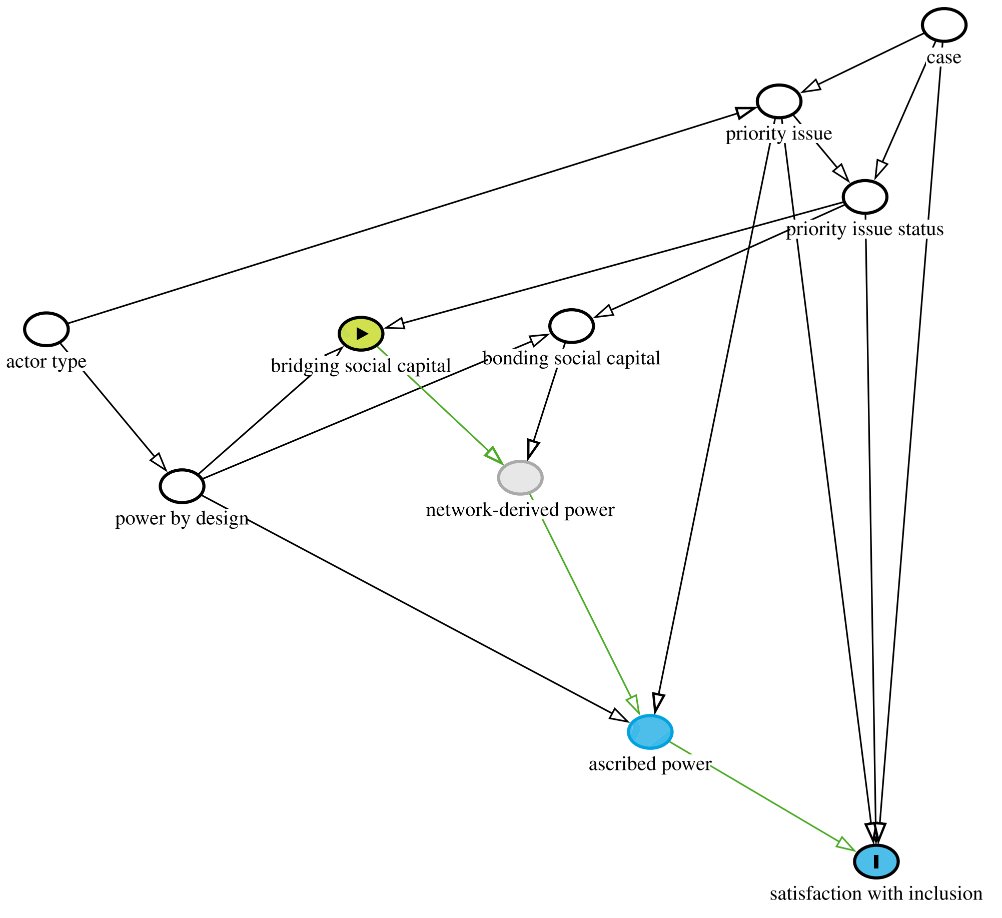

FIGURE 2 Directed acyclic graph illustrating the causal model assumed for analysis at the actor level. For illustrative purposes, bridging social capital is set as exposure (green) and satisfaction with inclusion in the governance process as the outcome (blue). The green path illustrates the total effect of bridging social capital, given all variable with circles outlined in black are adjusted for. Gray variables are unobserved constructs.

(eg. if procedural justice is higher on the case level). Given our DAG, these assumptions mostly matter in making it necessary to adjust for the priority issue of an actor in modeling satisfaction with inclusion as we also assume that the issue an actor prioritizes has influence on power (as some issue may for example be prioritized in legal frameworks). Not adjusting for priority issue opens a backdoor path from social capital to satisfaction via ascribed power.

Fourth, beyond which issue an actor prioritizes, how an actor individually evaluates the status of the issues they prioritize matters for our causal model. We assume that priority issue status influences both an actor's satisfaction with inclusion in the governance process as well as, based on the risk hypothesis introduced in the theory section, their preferences for bonding or bridging social capital. This makes it necessary to adjust for priority issue status of an actor in addition to which issue an actor prioritizes per se.

Statistical model

Model specification

As we model power as both an outcome of bonding and bridging social capital and a predictor for inclusion, we utilize a multivariate model, combining two generalized linear models.

In the first part of the model, our outcome variable is ascribed power of an actor as a count of nominations as influential. As a count variable, we model it using a (zero-inflated) Poisson regression model. In the second part of the model, our outcome variable is satisfaction with inclusion in the governance process. It is an ordinal variable on a 4-point Likert scale. In order to adequately model how it is associated with our predictors of interest, we therefore use an ordinal regression model. Specifically, we use a cumulative ordinal regression model, which is a natural choice for the Likert or Likert-style variables we analyze (Bürkner & Vuorre, 2019).

Our analysis is a prime candidate for multi-level modeling: We analyze actors distributed across 10 cases, while also taking into account that satisfaction may vary depending on the top priority issue of actors. Issues are nested in cases, but not all issues occur in every case.

Further, there are likely network dependencies within our data in relation to satisfaction. Actors with higher satisfaction might cluster together in collaboration networks, adding a network dimension to our multi-level modeling. We follow Tranmer et al. (2014) in specifying a multi-membership model component to account for such network dependencies based on the (multiple) membership of each actor among all existing ego networks in the collaboration network. The sensitivity of our results regarding the inclusion of multi-membership terms for network dependency is reported in the online appendix. Generally, including the multi-membership terms does not alter the fundamental tendencies in results but increases uncertainty in somewhat, which is why we conservatively chose to report the multi-membership models here.

Combining all of this, we use a Bayesian multivariate, multi-membership, multi-level regression model (Bürkner & Vuorre, 2019; Tranmer et al., 2014). In reporting the model in the following, we follow the recently proposed Bayesian Analysis Reporting Guidelines (BARG) (Kruschke, 2021). Table A1 in the appendix mirrors the list of key reporting points for the BARG in Kruschke (2021) and provides quick access to where the relevant points can be found within this article.

Returning to our multivariate model, in its first part, we model ascribed power $y_{\text{ascribed power}_i}$ of an actor i using a zero-inflated Poisson regression. We use a zero-inflated model with a specific zero inflation parameter p_i for the chance of a zero outcome in addition to the λ_i for the shape, because we expect a high number of actors not to be nominated as powerful, given often concentrated power distributions in governance systems. The model is of the following form:

$$
\begin{aligned}
y_{\text{ascribed power}_i} &\sim \text{zero}-\text{inflated}-\text{Poisson}\left(\lambda_i, p_i\right) \\
\lambda_i &= \alpha_{1[\text{case}]} + \alpha_{2[\text{issue}]} + \alpha_{3[\text{case,issue}]} \\
&\quad + \alpha_{4[\text{actor type}]} + \alpha_{5[\text{case,actor type}]} \\
&\quad + \beta_1 x_{\text{bridging}} + \beta_2 x_{\text{bonding}} \\
&\quad + \beta_3 x_{\text{bonding}} {}^{*} x_{\text{bridging}}
\end{aligned} \tag{1}
$$

For the second part of our multivariate model, we model satisfaction with inclusion in the governance process in a cumulative ordinal regression model. The model takes the following form to model the probability of each of our outcomes Y for an actor taking the ordered category value k, given a linear predictor η,

$$
Pr(Y = k \mid \eta) = F\left(\tau_k - \eta\right) - F\left(\tau_{k-1} - \eta\right) \tag{2}
$$

where F is the cumulative distribution function and τ_k indicates one of $K=3$ thresholds, which split the assumed latent distribution of the outcome into the four measured categories. The linear predictor η encodes our hypotheses about the influence of ascribed power and power by design in the β parameters of the model. For our outcome of interest in this part of the model, satisfaction of an actor with their inclusion in the governance process, the linear predictor $\eta_{\text{inclusion}}$ is of the form:

$$
\begin{aligned}
\eta_{\text{inclusion}} = {} & \alpha_{6[\text{case}]} + \alpha_{7[\text{issue}]} + \alpha_{8[\text{case,issue}]} + \alpha_{8[\text{actor type}]} + \alpha_{9[\text{ego net membership}]} \\
& + \beta_4 x_{\text{ascribed power}} + \beta_5 x_{\text{priority issue status}}
\end{aligned} \tag{3}
$$

The a parameters in both regression models stand in for a number of multi-level parameters of the model (with multi-membership possible in the case of a_9). We modeled varying intercepts for all multi-level blocks. We also modeled varying slopes between actor types for all main effects. We chose our final multi-level specification mainly based on comparing goodness of fit based on leave-on-out cross-validation (LOO) statistics between models with different degrees of varying effects. Generally, model fit improved in our models with the inclusion of varying effects, except for the zero-inflation parameter for the poisson model, which we did not model to vary for this reason. Varying zero inflation (e.g., across cases) did lead to a decrease in model fit, indicating that the variance from the baseline probability for zero inflation was already captured in the rest of the model.

The linear model in equation (3) does not contain a standard intercept parameter. In the ordinal regression model, the thresholds parameters τ_k replace the intercept parameter and are estimated separately from the linear model. β_5 accounts for the effect of how actors assess the status of their top priority issue. As such, it models the effect of an ordered categorical variable and we use a monotonic effect to account for this (Bürkner & Charpentier, 2020).

Prior distributions and predictive checks

We use weakly informative normal (0,5) priors for all β parameters and normal (0,10) parameters for the α parameters of the model for ordinal regression model for inclusion. For the monotonic effect used in β_6, we relied on the `brms` default dirichlet(1) prior, assuming equal probability of increases in categories for all categories. For the zero-inflated poisson model for ascribed power, all β parameters are estimated for variables on a log scale. In this context, setting weakly informative priors roughly translated to normal (0,0.25) priors. For the nonvarying zero inflation parameter p_i, we set a Beta(1,3) prior.

Figure A3 in the appendix contains prior and posterior predictive checks of the model. These show that the priors used are indeed weakly (if even) informative. Before being updated with empirical data, the model does not predict the empirically observed outcome distribution well, but does stay within a sensible range. Prior predictions from the ordinal model overemphasizes the lowest and highest categories for satisfaction with inclusion, whereas prior predictions from the poisson model overestimate zero inflation and occasionally predict nonsensically large values for power. After being updated, both parts of the model achieve high predictive performance, indicating that the data contains enough information to overwhelm the prior.

Computation

We fit all models in the `R` (R Core Team, 2021) package `brms` (Bürkner, 2017; Bürkner, 2018). All modeling steps, including sensitivity of results to a number of parameter choices can be replicated using data and code provided in an open online repository under https://doi.org/10.5281/zenodo.8101717. The repository contains a high-level procedure to reproduce the online appendix for this article, which (beyond the results reported here) contains the main results for the article computed for all possible combinations of choices for symmetrization procedure (see Section Bonding and bridging), length of paths considered in betweenness score calculation (see Section Bonding and bridging), tie types considered in transitive closure (see Section Bonding and bridging) and inclusion of ego network multi-membership terms in modeling (see Section Model specification).

We fit models using Markov chain Monte Carlo (MCMC) to derive the posterior distribution, using four chains with 2000 iterations and a burn-in of 1000. $\widehat{R}$ values were consistently one for all parameters, indicating that chains converged successfully. Tail effective sample size (ESS) was well above the recommended 400 (Vehtari et al., 2021) for all parameters and is reported for main parameters the online appendix.

Posterior distribution

Figures A4 and A5 and Table A2 in the appendix show posterior distributions of the primary parameters of the model (parameter groups τ and β). The online appendix contains further information on ESS and R-hat statistics.

Sensitivity checks

The posterior is not sensitive to alternative prior specifications. Introducing variation in prior settings by both making weakly informative priors broader or more restrictive as well as for introducing variation to default prior settings does not fundamentally alter the posterior distribution of parameters (Figures A6 and A7 in the appendix). However, especially for broader prior distributions entailing a priori likely ranges of possible values well beyond what would make any substantive sense (such as ascribed power scores orders of magnitudes higher than what is possible for an actor to achieve), some alternative prior settings do lead to model fitting issues indicating nonconvergence.

RESULTS

Table 3 gives a high-level overview over the results of our hypothesis tests.

Network embedding and power

Figure 3a,b displays the marginal and conditional effects (as posterior predictions) of bonding and bridging on network-derived power. Effects are illustrated stratified across different levels of power by design (approximated by actor type) and are generally robust in their trends across these levels. For bonding, a likely positive and substantial effect on network-derived power can be recognized. Bridging, however, has no discernible effect on actors' network-derived power.

Further, Figure 3c illustrates a strong association of actors' levels of power by design with our measurement of ascribed power. Public actors and particularly higher level administration public actors are assigned higher levels of ascribed power compared with other types of actors. However, the associated insecurity (captured in the 88% credible interval) is relatively high, indicating a clear trend but uncertain magnitude of the trend. Figure 3c thus lends credence to our approach of controlling for power by design via actor type to estimate the effect of network embedding on network-derived power, as a testable assumption of our DAG.

Figure 3d displays the results regarding Hypothesis 5 about actors combining both high amounts of bonding and bridging social capital. We find indications that the interaction of bridging and bonding is likely positive. However, the magnitude of the effects is so small, that it does hardly matter, which is especially visible on the outcome scale (as plotted in Figure 3d).

Combined the figure elements a, b, c, and d shows strong support for our Hypothesis 3 on the importance of bonding ties as a source of network-derived power. For bridging ties, no clear effect on network-derived power can be recognized. As such, the Hypothesis 1 is not supported by the results. Hypothesis 5 is also not supported by our results.

Translation of network embedding into inclusion via power

Figure 4a shows the marginal effect of ascribed power on actors' satisfaction with inclusion in the governance process. The figure shows one vector of k of probabilities for every ordinal category modeled.

TABLE 3 Overview over results for tested hypotheses and their associated processes.

Hypothesis	Process tested	Result
1	Bridging → Power	No support
2	Bridging → Power → Inclusion	Weak support
3	Bonding → Power	Strong support
4	Bonding → Power → Inclusion	No support
5	Bridging × bonding → Power	No support

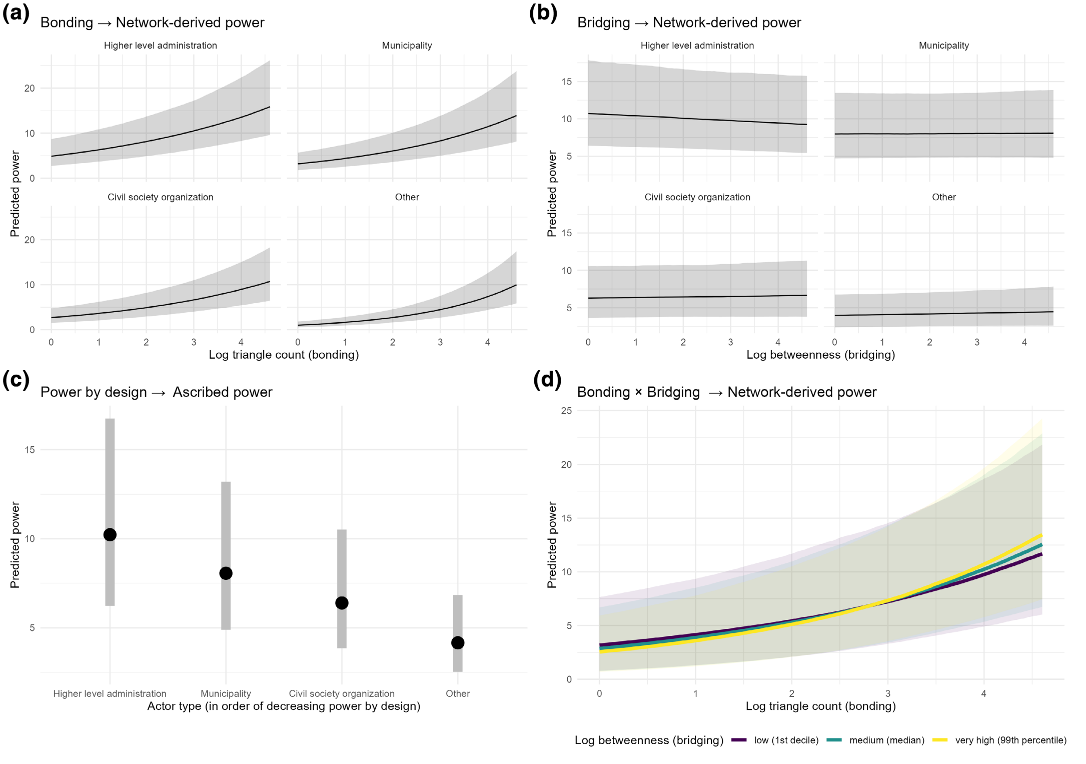

FIGURE 3 Bonding (a) and bridging (b) social capital as sources of network-derived power and association of power by design of actors with ascribed power (c). Gray areas denote 88% credible intervals. (a) Marginal effect of bonding, measured as log triangle counts on network-derived power, by actor type. (b) Marginal effect of bridging, measured as log betweenness within an actor's ego network of order 2 on network-derived power, by actor type. (c) Conditional effect of power by design, approximated by actor type, on ascribed power. (d) Marginal effect of bonding by different levels of bridging in sample distribution (main effect plus interaction).

These probabilities sum to one for every single configuration of inputs. k_i is then the probability of the ith category, given the inputs. To interpret the figure, comparing the likelihood of an actor's satisfaction falling within the highest versus the lowest category with increasing ascribed power is illustrative. Our results show that satisfaction with inclusion is a function of power, although to what degree is fundamentally uncertain. Clearly, with increased network-derived power, the probability of being very unsatisfied with inclusion (falling into the lower category) decreases substantially.

The link established between network embedding and power can now be combined with the link established between power and satisfaction with inclusion to assess how network embedding translates into satisfaction with inclusion.

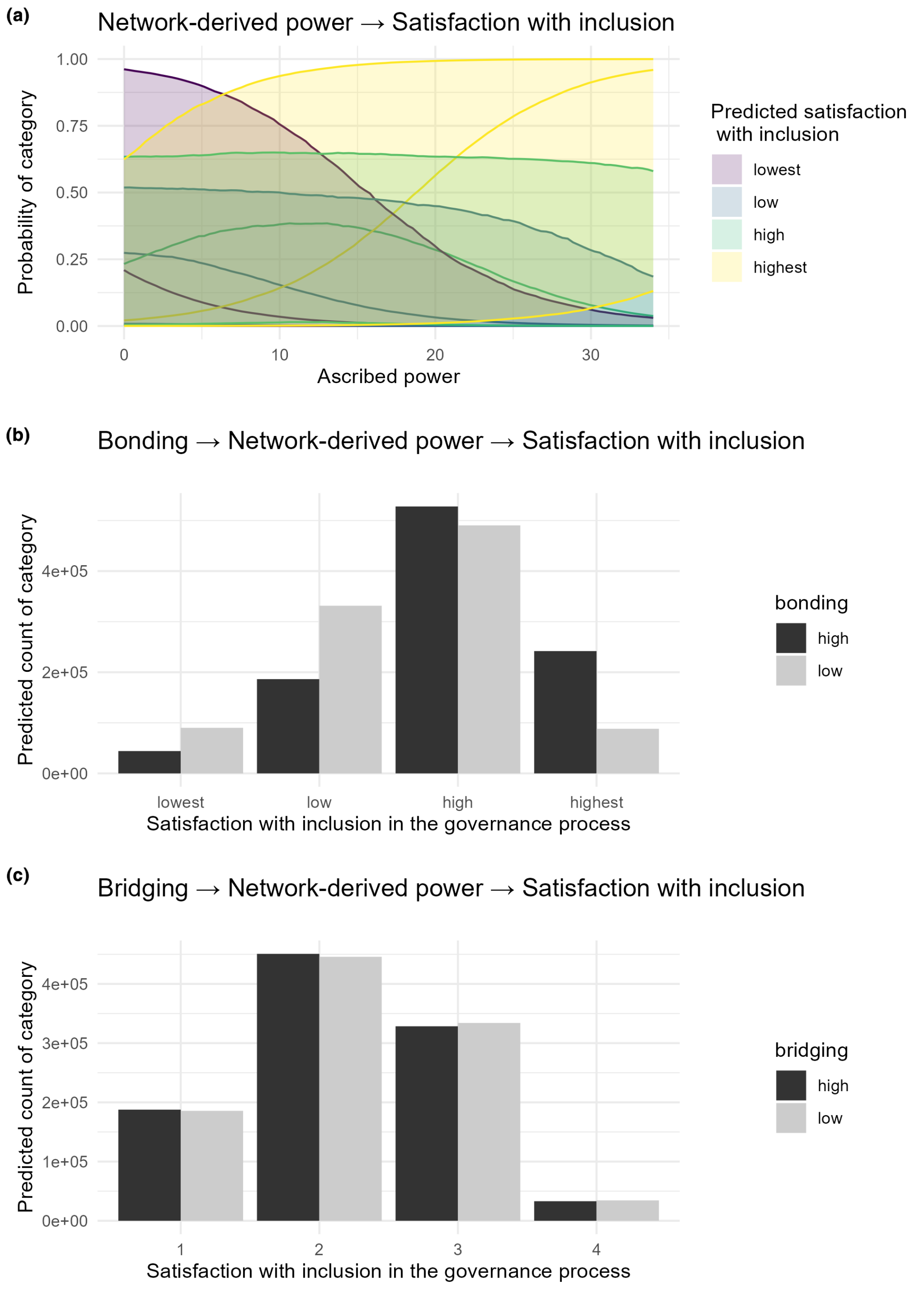

FIGURE 4 Effects (posterior predictions) of network-derived power (a) as well as bonding (b) and bridging (c) on satisfaction with inclusion in the governance process. (a) Marginal effect of ascribed power on satisfaction with inclusion in the governance process for an actor. Solid lines within ribbons show the median posterior density. Ribbons indicate the 88% credibility interval. (b) Translation of bonding, measured as log triangle count into satisfaction with inclusion in the governance process, via ascribed power. Example actor: Municipality in Reussebene case, priority issue biodiversity, all other characteristics at sample means. First differences between bonding at the second and eighth decile of sample distribution are shown. Predictions based on forward propagating predictions in the multivariate model based on 1000 draws from the posterior for the link between bonding and power. (c) Translation of bridging, measured as log betweenness within an actor's ego network of order 2, via ascribed power. A procedure analogous to (b).

Figure 4b,c illustrate how bonding and bridging ties contribute to increasing the level of satisfaction with inclusion in the governance process through network-derived power. The figures show differences in the predicted distributions of satisfaction with inclusion for a comparison of two average, fictive actors with either low or high levels of bonding, respectively bridging ties, who are otherwise identical. Our results indicate that bonding ties translate markedly into satisfaction via power. For bridging, however, no effect can be found. We thus find support for Hypothesis 4 and do not find support for Hypothesis 2.

DISCUSSION AND CONCLUSION

Scientific knowledge of network governance processes and their relation to outcomes on a systemic level in sustainability and natural resource governance has been continuously growing (Bodin et al., 2019). There is considerably less evidence for how individual governance network embedding relates to actor-level outcomes (Lubell & Morrison, 2021; Scott & Thomas, 2017). Our study adds valuable evidence about the relationship between network embedding, power, and satisfaction with inclusion in sustainability governance from a rare multi-case study design.

We have explored network embedding as a specific source and consequence of power in polycentric sustainability governance in this study. To sum it up, network relations matter as a source of power for actors in polycentric sustainability governance. We can clearly see the effects of network embedding—independent of nonnetwork-derived power by design—across our 10 cases.

Only particular types of network ties have a meaningful impact on power in our cases. Based on the results, actors who wish to maximize their power in polycentric sustainability governance in situations such as the ones we studied should benefit from focusing on bonding ties in networks. Bridging ties did not increase or decrease actors' power and there is also no clear evidence of an interaction effect where hub or super-generalist (Olesen et al., 2007) actors with many bridging ties would benefit disproportionally from them to leverage their bonding ties, as suggested in some network theories of social capital (Burt, 2000).

We should, however, be very careful in generalizing these insights. The importance of bonding compared with bridging ties could be a consequence of the high complexity of polycentric sustainability governance of Swiss wetlands, which entails associated risk for actors, shaping network structures, and conditions under which actors operate (Berardo & Scholz, 2010). High complexity is commonly reported in polycentric sustainability governance settings and as such, the importance of bonding ties seems a credible result that might hold beyond our cases. However, it is important to keep in mind that our cases might simply be too small for actors to benefit from bridging ties. Our cases are all small- to medium-sized cases of wetland governance where actors in brokerage positions might not enjoy the same leverage they enjoy in settings where actors are more socially distant from each other. As such, our results might just as well suggest that there is a likely scale dependency to how network embedding translates into power, which is an interesting avenue for further research on this topic.

In addition, the relevance of bonding might be particularly high in the Swiss context. Traditions of direct democracy and Vernehmlassungsverfahren (formalized consultation procedures) traditionally lead to many veto points in Swiss governance processes (Papadopoulos & Maggetti, 2018). In such situations, actors might have a natural incentive to form bonding ties to keep control over the decision-making process. In other case settings, this effect is likely to be less pronounced. In addition to a scale dependency, this also opens up a further dimension for research on the translation of network embedding into power that takes into account the influence of institutional settings or political systems more broadly (Metz & Brandenberger, 2022).

A key limitation of our study design is that we were unable to investigate the exact processes of how bonding and bridging translate into network-derived power more deeply. We develop a theoretical understanding of the link between bonding, bridging, and power in this study. Combining this understanding with our ability to adjust for power by design, we are relatively sure, within the confines of our theoretical model, that we can demonstrate that networks are a specific source of framing and/or pragmatic power. We are also relatively sure that bonding social capital plays a big role in generating power and satisfaction with inclusion in our cases.

Given our model design, we could not distinguish to what extent network-derived power is sourced from pragmatic or framing power. Investigations into this link in complex governance systems would be a welcome next step in assessing trade-offs involved regarding effective and inclusive polycentric sustainability governance systems on the collective level (Lubell & Morrison, 2021; Scott & Thomas, 2017). In the same vein, we also could not investigate how exactly bonding social capital led to power for actors that were attributed to them by others in our cases. Given our survey design, we cannot rule out that participants might have been primed to overemphasize their collaboration partners as more powerful due to recency effects. Further research should consider mixed methods or qualitative designs to investigate these questions. In the same vein, our measure of power by design is relatively crude and could be improved or supplemented by assigning power by analysis of legal text or institutional grammar (Siddiki et al., 2022).

A further limitation of our study relates to survey-based construction of the networks used to assess bridging and bonding. Social networks are not real—they are theoretical constructs approximated by observations in the broader sense (thus including surveys) and we should continue to refine tools to incorporate uncertainty stemming from this fact into our modeling (Hart, Weiss, et al., 2022). Tools to incorporate uncertainty in ties that can be incorporated into Bayesian workflows such as the R package `BisonR` (Hart, Franks, et al., 2022) or specifically tailored latent network models (De De Bacco et al., 2023) are emerging and promising for the future, although, for this analysis, there were no sufficiently robust implementations at the time of writing.

Our findings provide relatively robust evidence that power, its type, and source notwithstanding, is a key determinant of satisfaction with inclusion in the governance process. In light of questions of procedural justice, this is another illustration of a crucial normative challenge for polycentric governance systems. Recognizing that power asymmetries are the norm in such systems (Mancilla García & Bodin, 2019; Morrison et al., 2019), we need to balance effectiveness and procedural justice while taking into account the effect of power asymmetries on both.

For future research on the effect of network embedding on outcomes in governance systems, our study illustrates that it is crucial that we do not ignore power when assessing the effects of network embedding both for individual actors and at the system level. Governance networks are sources and results of power distributions.

For the practice of sustainability governance, the theoretical benefits of collaborative, polycentric, and networked governance arrangements at the systemic level are often argued to be increased legitimacy, effectiveness, and adaptiveness by including a diversity of actors. Given the role of governance networks as sources and results of power, our study shows, these benefits should not be taken for granted.

FUNDING INFORMATION

This project was supported by the Swiss National Science Foundation 10 (SNSF) (grant no. 172665) and a Bridge Postdoc grant by the Digital Society Initiative of the University of Zurich.

ACKNOWLEDGMENTS

Open access funding provided by Universitat Zurich.

CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

All modeling steps can be replicated using anonymized data and code provided in a publicly accessible online repository under https://zenodo.org/record/8101718.

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ENDNOTES

[1] Data set: https://opendata.swiss/de/dataset/bundesinventar-der-auengebiete-von-nationaler-bedeutung, last accessed October 26, 2022.

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How to cite this article: Angst, Mario and Martin Nicola Huber. 2024. "Who is Satisfied With Their Inclusion in Polycentric Sustainability Governance? Networks, Power, and Procedural Justice in Swiss Wetlands." *Policy Studies Journal* 52(1): 139–167. https://doi.org/10.1111/psj.12515.

APPENDIX A

TABLE A1 Bayesian Analysis Reporting Guidelines list of key reporting points, based on Kruschke (2021) and where these points are addressed in the article.

Bayesian Analysis Reporting Guidelines list of key reporting points BARG reporting step	Article
Step 1. Explain the model	
A. Data variables. Explain the dependent (predicted) variables and independent (predictor) variables.	Section Variables and measurement. Dependent variable: subsection Satisfaction with inclusion in the governance process, Predictors: subsection Bonding and bridging, Ascribed general power, and Priority issue status, Distributions: Figure A1
B. Likelihood function and parameters. For every model, explain the likelihood function and all the parameters, distinguishing clearly between parameters of primarily theoretical interest and ancillary parameters. If the model is multi-level, be sure that the hierarchical structure is clearly explained, along with any covariance structure if multivariate parameter distributions are used.	Section Model specification
C. Prior distribution. For every model, explain and justify the prior distribution of the parameters in the model.	Subsection Prior distributions and predictive checks
D. Formal specification. Include a formal specification (mathematical or computer code) of the likelihood and prior, located either in the main text or in the publicly and persistently accessible online supplementary material.	Section Model specification, Equations 1–3, computer code accessible in online repository https://doi.org/10.5281/zenodo.8101717
E. Prior predictive check. Especially when using informed priors but even with broad priors, it is valuable to report a prior predictive check to demonstrate that the prior really generates simulated data consistent with the assumed prior knowledge.	Subsection Prior distributions and predictive checks, Figure A3
Step 2. Report details of the computation	
A. Software. Report the software used, including any specific added packages or plugins.	Subsection Computation
B. MCMC chain convergence. Report evidence that the chains have converged, using a convergence statistic such as PSRF, for every parameter or derived value.	Subsection Computation
C. MCMC chain resolution. Report evidence that the chains have high resolution, using the ESS, for every parameter or derived value.	Subsection Computation, online appendix
D. If not MCMC.	Not applicable
Step 3. Describe the posterior distribution	
A. Posterior predictive check. Provide a posterior predictive check to show that the model usefully mimics the data.	Subsection Prior distributions and predictive checks, Figure A3
B. Summarize posterior of variables. For continuous parameters, derived variables and predicted values report the central tendency and limits of the credible interval. Explicitly state whether you are using density-based values (mode and HDI) or quantile-based values (median and ETI), and state the mass of the credible interval (e.g., 95%).	Figures A4 and A5, and Table A2
C. BF and posterior model probabilities.	Not applicable
Step 4. Report decisions (if any) and their criteria	Not applicable

(Continues)

TABLE A1 (Continued)

Bayesian Analysis Reporting Guidelines list of key reporting points	
BARG reporting step	**Article**
Step 5. Report sensitivity analysis	
A. For broad priors. If the prior is intended to be vague or only mildly informed so that it has minimal influence on the posterior, show that other vague priors produce similar posterior results.	Figure A3
B. For informed priors.	Not applicable
C. For default priors. If using a default prior, show the effect of varying its settings. Be sure that the range of default priors constitutes theoretically meaningful priors and consider whether they mimic plausible empirically informed priors.	Figures A6 and A7
D. BFs and model probabilites	Not applicable
E. Decisions	Not applicable
Step 6. Make it reproducible	See online repository https://doi.org/10.5281/zenodo.8101717

Note: We also include points and steps not applicable in order to be transparent about what we deem not applicable. The requirements of step 6 (reproducibility) are addressed in an online repository accessible at https://doi.org/10.5281/zenodo.8101717.

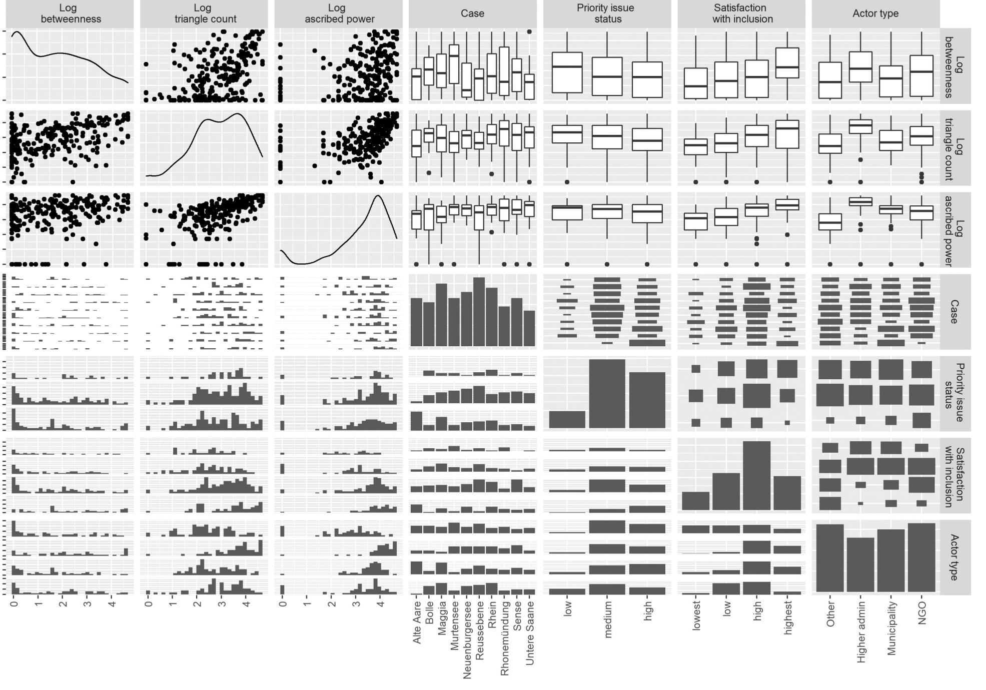

FIGURE A1 Distributions (diagonal) and pairwise interactions (off diagonal) for all variables used in modeling. Only complete cases ($n = 243$) are shown.

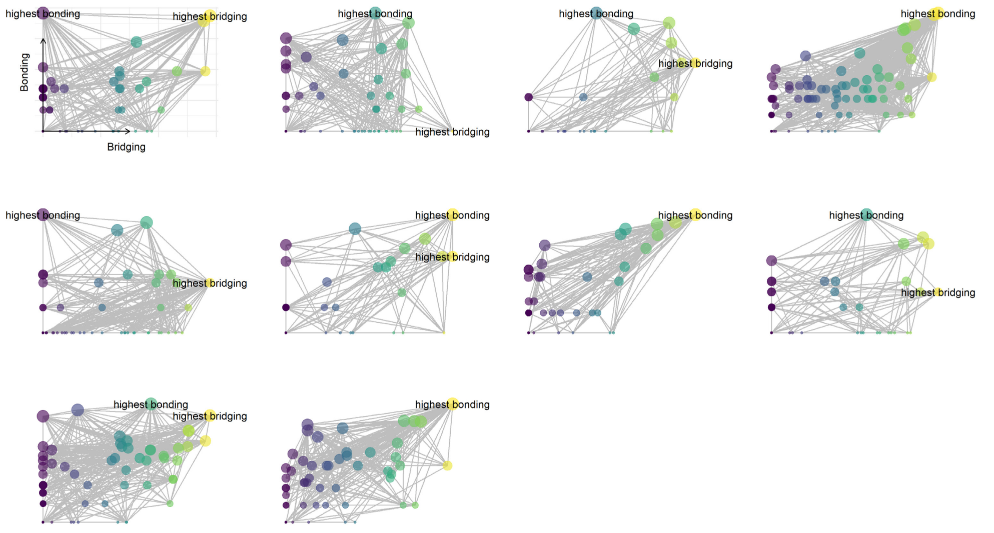

FIGURE A2 Network plots of undirected collaboration networks (combining positive, neutral, and negative ties) across all 10 cases with functional structure in terms of bridging versus bonding social capital emphasized in node placement. Isolates are not shown. If only the highest bonding is labeled, the highest bonding equals the highest bridging in the case.

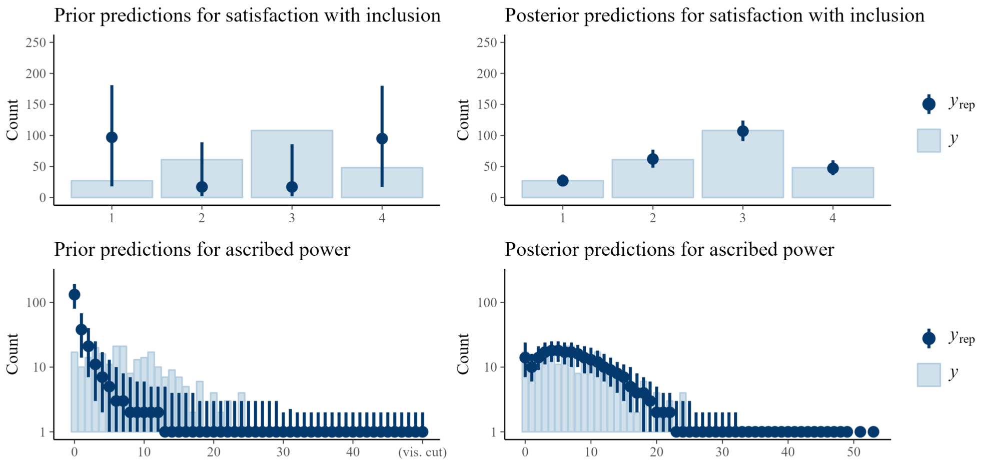

FIGURE A3 Prior (left panel) versus posterior predictions (right panel) of reported regression model (y_{rep} vs. empirical distribution y) of outcome categories.

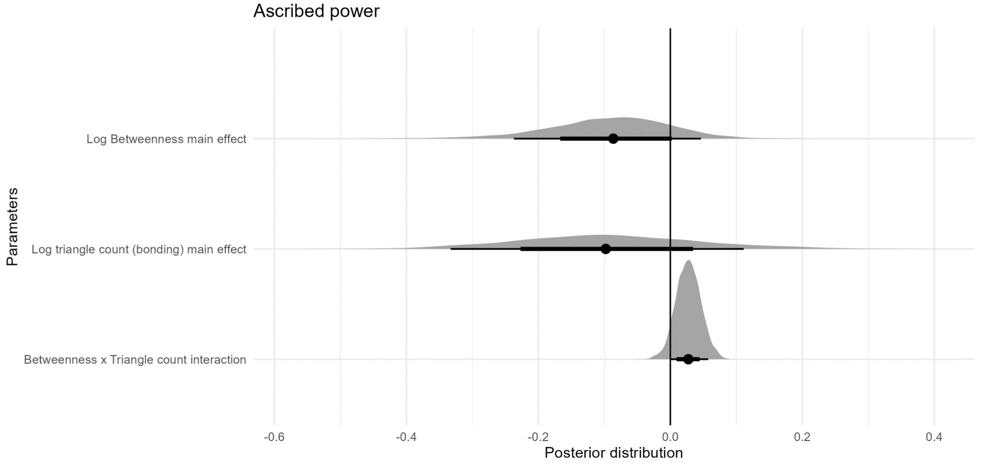

FIGURE A4 Posterior distributions of β model parameters for zero-inflated ordinal regression part of the model (predicting ascribed power). Dots indicate median high posterior density interval values. Thick horizontal bars indicate 66% credible intervals and thin horizontal bars 88% credible intervals.

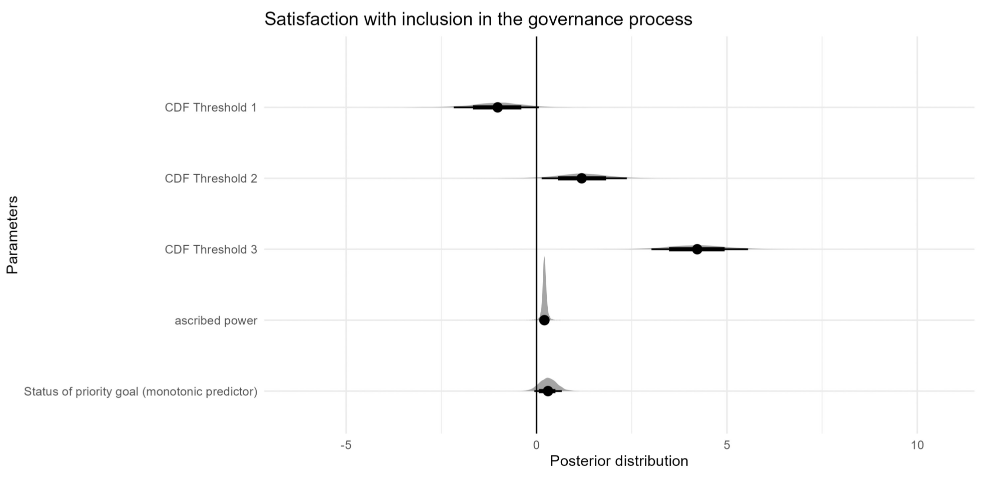

FIGURE A5 Posterior distributions of β and CDF threshold model parameters for zero-inflated ordinal regression part of the model (predicting satisfaction with inclusion in governance process). Dots indicate median high posterior density interval values. Thick horizontal bars indicate 66% credible intervals and thin horizontal bars 88% credible intervals.

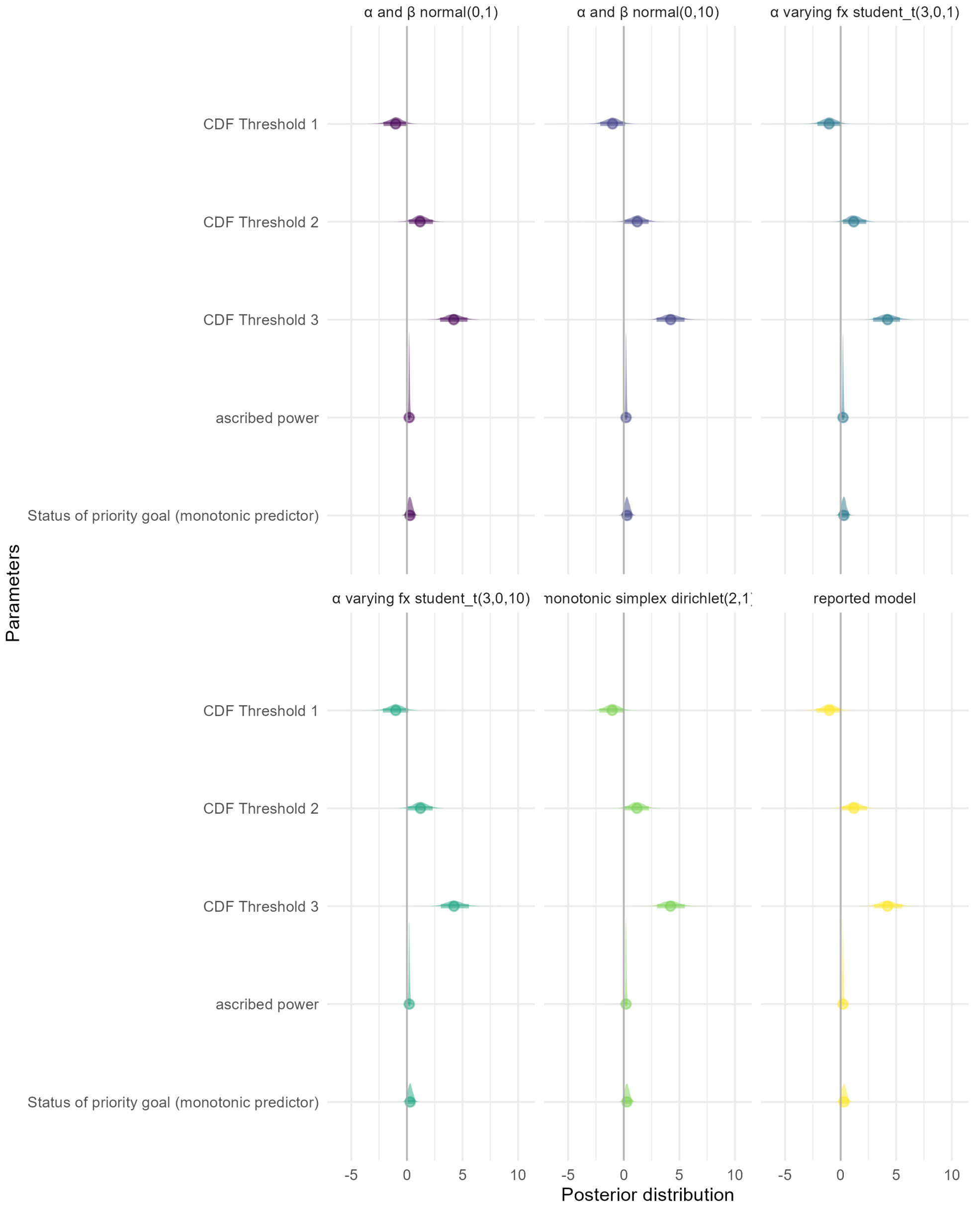

FIGURE A6 Sensitivity of posterior distribution of β and α parameters to different prior settings for ordinal regression model parameters. Variation to the reported model was introduced both by varying priors for weakly informative α and β parameters and by introducing variation on default parameters for the Dirichlet distribution on the monotonic effect simplex parameter and for the Student *t* distribution on the varying intercept and slope parameters of the multi-level model. The highest posterior density intervals are shown. Point estimates (dots) are medians. Thick horizontal lines indicate 88% credible intervals. Sensitivity was assessed on a model without imputation for computational efficiency.

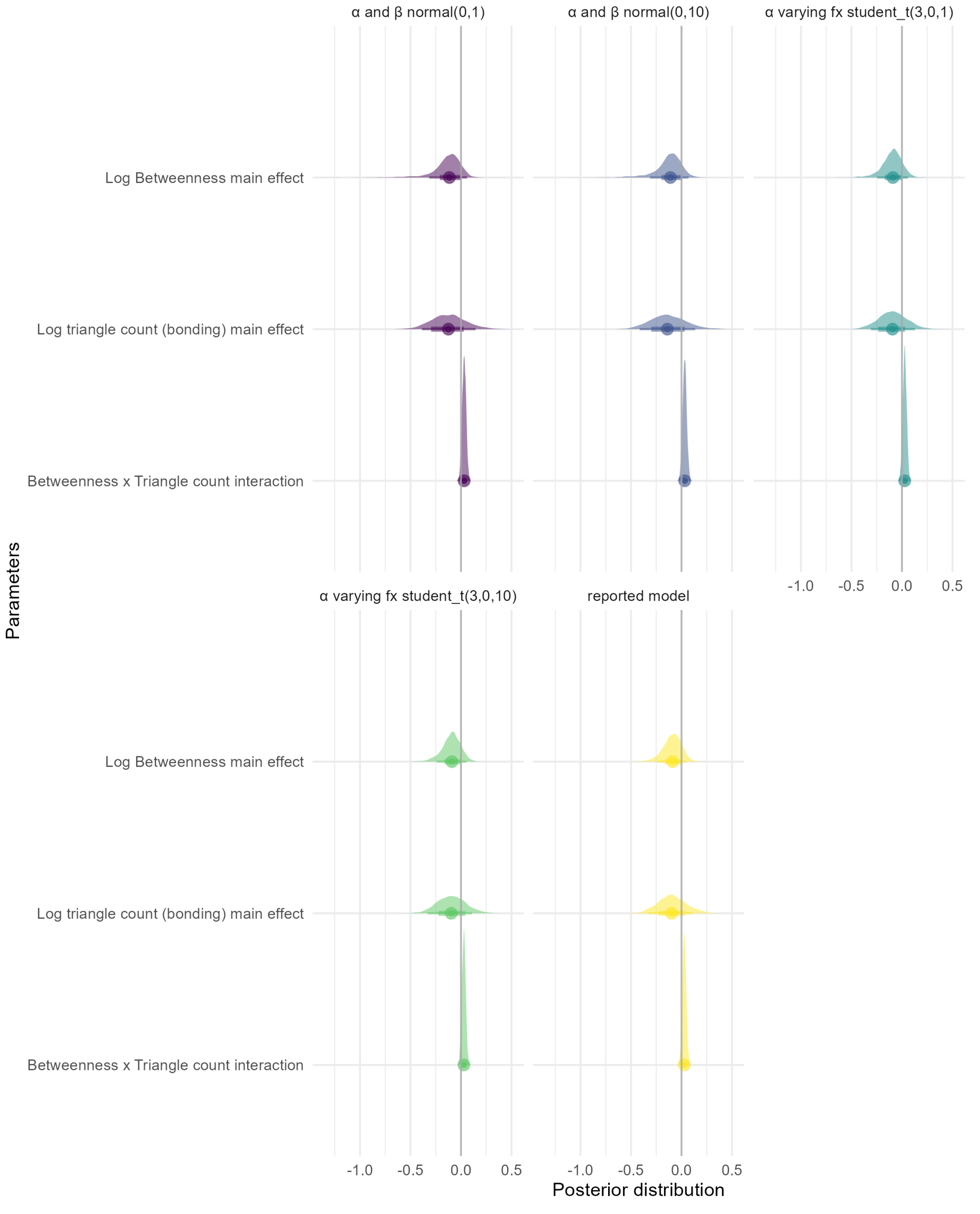

FIGURE A7 Sensitivity of posterior distribution of β and α parameters to different prior settings for zero-inflated Poisson model parameters. Variation to the reported model was introduced both by varying priors for weakly informative α and β parameters and for the Student *t* distribution on the varying intercept and slope parameters of the multi-level model. The highest posterior density intervals are shown. Point estimates (dots) are medians. Thick horizontal lines indicate 88% credible intervals. Sensitivity was assessed on a model without imputation for computational efficiency.

TABLE A2 Posterior distribution of key model parameters in summary form (median and 88% credible interval of highest posterior density interval).

Parameters	Median [88% CI] HPDI
Satisfaction with inclusion model (ordinal)	
CDF threshold 1	−1.02
	[−2.17; 0.06]
CDF threshold 2	1.19
	[0.13; 2.37]
CDF threshold 3	4.22
	[3.02; 5.55]
Ascribed power	0.21
	[0.12; 0.31]
Status of priority issue (monotonic predictor)	0.30
	[−0.06; 0.66]
Ascribed power model (zero-inflated Poisson)	
Intercept	0.63
	[0.10; 1.20]
Log betweenness	−0.09
	[−0.24; 0.05]
Log triangle count	−0.10
	[−0.33; 0.11]
Triangle count × betweenness interaction	0.03
	[−0.00; 0.06]

Note: We urge caution, as these are hard to interpret outside the context of the likelihood.