RESEARCH ARTICLE

Policy learning as complex contagion: how social networks shape organizational beliefs in forest-based climate change mitigation

Antti Gronow[1] · Maria Brockhaus[2] · Monica Di Gregorio[3] · Aasa Karimo[1] ·
Tuomas Ylä-Anttila[1]

© The Author(s) 2021

Abstract
Policy learning can alter the perceptions of both the seriousness and the causes of a policy problem, thus also altering the perceived need to do something about the problem. This then allows for the informed weighing of different policy options. Taking a social network perspective, we argue that the role of social influence as a driver of policy learning has been overlooked in the literature. Network research has shown that normatively laden belief change is likely to occur through complex contagion—a process in which an actor receives social reinforcement from more than one contact in its social network. We test the applicability of this idea to policy learning using node-level network regression models on a unique longitudinal policy network survey dataset concerning the Reducing Deforestation and Forest Degradation (REDD+) initiative in Brazil, Indonesia, and Vietnam. We find that network connections explain policy learning in Indonesia and Vietnam, where the policy subsystems are collaborative, but not in Brazil, where the level of conflict is higher and the subsystem is more established. The results suggest that policy learning is more likely to result from social influence and complex contagion in collaborative than in conflictual settings.

Keywords Advocacy coalition framework · Complex contagion · Policy learning · Social influence · Social network analysis

---

✉ Antti Gronow
antti.gronow@helsinki.fi

Maria Brockhaus
maria.brockhaus@helsinki.fi

Monica Di Gregorio
M.DiGregorio@leeds.ac.uk

Aasa Karimo
aasa.karimo@helsinki.fi

Tuomas Ylä-Anttila
tuomas.yla-anttila@helsinki.fi

[1] Faculty of Social Sciences, University of Helsinki, Helsinki, Finland

[2] Department of Forest Sciences, University of Helsinki, Helsinki, Finland

[3] School of Earth and Environment, University of Leeds, Leeds, UK

Introduction

Policy learning is an area of study that has received increasing attention in the public policy literature (Riche et al., 2020). Policy learning as the update of beliefs has been explored, for example, in the context of environmental policy (Gerlak et al., 2018; Wagner & Ylä-Anttila, 2018), collaborative governance (Leach et al., 2013), and the European Union (Zito & Schout, 2009). The growing popularity of research on policy learning led Dunlop and Radaelli (2018) to argue that policy learning has developed into an analytical framework of its own. When policy learning alters the perceptions of the seriousness and causes of a policy problem, it can also alter the perceived need to do something for the problem in question (Weible et al., 2016, 10; Bennett & Howlett, 1992). Although learning might also strengthen a particular status quo, most scholars tend to think of policy learning as a source of incremental policy changes that result from the adoption of new public policies (Boushey, 2010). For example, the Advocacy Coalition Framework (ACF) contends that policy learning can lead to changes in the policies that are implemented (Sabatier, 1998). Learning can also lead to the convergence of policy beliefs, which can foster building consensus and mobilizing for collective action (Leach et al., 2013). Ideally, during the process of learning policy, the actors develop a comprehensive and accurate understanding of the issues involved (Leach et al., 2013). Although the importance of policy learning has generally been acknowledged, the evidence of the conditions that facilitate learning is scattered (Riche et al., 2020). Researchers have shown that the diversity of participants, their perceived trustworthiness, and the procedural fairness of governance contribute to policy learning (Leach et al., 2013). Moreover, Heikkila et al. (2014) suggested that policy learning can come about because of cross-coalitional learning processes. We argue that there is one source or trigger of policy learning that, thus far, has been overlooked by most researchers: social influence that takes places via networks.

Many theories employ concepts and ideas derived from network analysis where the focus is on how relationships between policy actors contribute to the policy process. It has been argued that networks may help actors in developing a common understanding of policy problems, and they may also support joint action (Riche et al., 2020). Newig et al. (2010) proposed that network structures might affect policy learning, but the authors did not measure what the actual effects are. Thus far, relational approaches to policy processes have mainly focused on explaining how policy beliefs affect the coordination of political action. Such mechanisms of *social selection*—actors choosing to have ties with those whose beliefs are similar to their own—are a recurrent phenomenon in all kinds of social networks (Lewis et al., 2012). For example, the so-called belief homophily thesis of the ACF implies that coordination of political action results primarily from similar beliefs (Gronow & Ylä-Anttila, 2019; Weible & Ingold, 2018). The assumption then is that policy actors choose to collaborate with other actors because of belief similarity. However, we argue that researchers of policy learning—conceptualized as changes in beliefs—should pay attention to another social mechanism, that of *social influence*. In the case of policy learning, social influence denotes the mechanism by which the relations a policy actor has with others have effects on how its beliefs change.

When previous research has recognized the importance of policy learning in the context of network relations, the evidence for network effects has been implicit (Riche et al., 2020, 3). Furthermore, we argue that when policy learning results from network relations, learning as the update of beliefs takes place through a process called complex contagion. This concept refers to instances in which social influence takes place only when there is social

reinforcement from multiple sources in the actor's social network (Centola & Macy, 2007). Research suggests that such multiple reinforcement is necessary to change beliefs that are normatively laden and, for this reason, more difficult to change than other types of beliefs (ibid.). Policy beliefs often fulfill this normativity criterion. Complex contagion is different from "simple" contagion in which, for example, information spreads in a social network through single contacts. The developers of the idea of complex contagion posited that the higher the absolute number of social contacts advocating a belief change, the more likely it is that belief change will occur (Centola & Macy, 2007). We argue that social reinforcement is likely to lead to policy learning the larger the share of one's social contacts that reinforce a certain belief.

Measuring belief changes over time and testing for the effect of social influence requires a policy subsystem in which policy learning takes place and where data collection on actors' beliefs and social networks can repeatedly be undertaken. The policy domain of Reducing Emissions from Deforestation and Forest Degradation (REDD+), which was established under the United Nation's Framework Convention on Climate Change (UNF-CCC), represents such a testing ground. We apply our ideas in the context of three countries in the Global South: Vietnam, Indonesia, and Brazil. A unique contribution to advancing the understanding of policy learning is that the data were collected at two points in time, which enables us to infer the direction of causality in the processes we study. To our knowledge, this is the first time that the complex contagion idea has been tested in a policy learning setting. However, we also acknowledge that other, context-dependent factors may play a role in policy learning. In the next section, we present the theoretical framework and then discuss the data and methods. After presenting the results, we conclude with lessons learned and outline ideas for future research.

Theoretical framework and the research hypotheses

Policy learning as belief change

Policy learning refers to the acquisition of new ideas, information, and beliefs when they relate to policies or decision-making processes (Gerlak et al., 2018). Thus, policy learning has to do with the cognitive and social dynamics of belief update (Moyson, 2017). Learning changes how things are seen and how goals are pursued. Traditionally, learning has applied to individuals, but recent advances have emphasized that organizations also adapt to changes in their environments and are therefore learning systems that can hold collective beliefs (Williams, 2001, 69). Our focus is on this level of organizational beliefs.

Policy process theories often emphasize the importance of policy learning for policy change (Bakır, 2017). One such theory is the ACF, which assumes that the relevant level of analyses of policy processes is a policy subsystem (Sabatier, 1998). Subsystems consist of all the policy actors that have a stake in a certain policy field. For example, climate change policy or land use policy can be analyzed as a policy subsystem, which consists of all the organizations (e.g., government agencies, non-governmental organizations, and businesses) that are engaged in shaping related policies (Gronow & Ylä-Anttila, 2019). According to the ACF, policy actors coordinate and advocate for specific policy goals through coalitions whose composition reflects their shared policy beliefs (Sabatier, 1998). Changes in the beliefs held by the actors in a policy subsystem often precede policy change (Leifeld,

2013). Belief change can, for example, change the relative size of coalitions if changes in beliefs lead actors to defect and join a new coalition.

Although policy beliefs and learning are a central feature of the ACF, scholars working within this framework have mainly investigated instances of social selection. This concept denotes the phenomenon where actors choose to engage in relationships with others whose attributes are similar to their own (Lewis et al., 2012). A central assumption of the ACF is that shared policy beliefs unite actors into advocacy coalitions through a mechanism of social selection: actors select collaboration partners because of belief similarity. Changed beliefs can therefore lead to changes in the collaboration ties that coalitions are based on. We argue, however, that another mechanism recurrent in social networks, social influence, may play an important role in policy learning. Social influence occurs when an actor's behaviors or beliefs change so that they become similar to those of its network contacts. In the context of policy learning, this means that actors update their beliefs based on the beliefs that their contacts hold. Previous research has investigated factors such as trust and the role of central actors in facilitating policy learning (Riche et al., 2020). However, the way that the links between organizational actors contribute to the updating of policy beliefs has so far been overlooked. Next, we outline the why it makes sense to analyze social influence as a driver of policy learning in the ACF context.

Policy learning and the ACF

The ACF suggests that belief-oriented segregation is a common phenomenon in networks because of a tendency for belief homophily, especially when there are conflicts over core values. This means that there is a tendency to collaborate with actors that share similar policy beliefs because joining forces makes it more likely that actors can push for policies that align with their beliefs. Beliefs and strategic concerns (how to realize policies based on those beliefs) thus give rise to the network-level result of segregation based on beliefs (Henry et al., 2020). Ingold et al. (2019) argue that the centrality of beliefs for ACF begs the question of how beliefs are acquired and updated. They also acknowledge that while ACF assumes that learning is a critical part of this process, little is known about factors that facilitate learning and lead to alterations in policy beliefs.

In addition, Henry et al. (2020, 3) argue that ACF's focus on belief homophily has had the unfortunate consequence of detracting attention from the possibility that policy actors' beliefs can also evolve due to the influence of their network connections. In the ACF perspective, the ones who learn by updating their beliefs are individuals, but the aggregated learning at the level of collective actors, or coalitions, is the main concern. We hasten to add that the policy actors of interest are usually organizational actors rather than individuals. Thus, individuals represent organizations (i.e., ministries, NGOs, businesses, etc.) and rarely engage in purely private thinking—at least not in private thinking that would contradict the beliefs of the organization. Therefore, our analysis focuses on organizational beliefs (cf. Williams, 2001).

Belief homophily and policy learning may work together through a process of coevolution if learning makes actors' beliefs more similar over time. However, Henry et al. (2020) found evidence of belief homophily but not of learning. Thus, what drives network formation in their study is not so much that that actors would change their beliefs by becoming similar with their network partners, but that actors choose to establish connections with those whose beliefs are already similar to their own. Henry et al. (2020, 24) therefore conclude that "the learning of policy beliefs is extremely difficult." The authors measure

learning is by analyzing whether professional movements between organizations make organizational beliefs converge. Thus, it counts as policy learning if an individual moves from one organization to another and then the beliefs reported by the latter organization change as a result. They find only a small and statistically non-significant negative association between these two factors. While this is valuable evidence, it remains unclear whether this measure captures the effects of policy learning on the organizational level. It may be too much to ask that a single individual would change the stances of an organization by being recruited by this organization because organizational beliefs are more than the sum of the beliefs of their representatives. Therefore, the jury is still out when it comes to the effects of social influence on policy learning. Most importantly, what is the exact mechanism through which social influence operates? We argue that complex contagion is at least a partial answer.

Policy learning and complex contagion

There are instances when social influence takes place because a single contact acts as a source of novel information or social pressure. For example, a single contact is sufficient for the transmission of information concerning new job opportunities (Guilbeault et al., 2018). Upon hearing information like this from a single person, one is likely to think the information is credible and may act upon it by applying for the job or by relaying the information further. Centola and Macy (2007) called such instances of social influence *simple contagions*. Centola and Macy argued that the diffusion of normatively laden beliefs and collective behaviors differs from the diffusion of information because such beliefs and behaviors spread through *complex contagion*. This concept refers to a process in which social reinforcement comes from several sources in an actor's network. When faced with novel ways of doing things and with innovative ideas, "[n]onadopters are likely to challenge the legitimacy of the innovation, and innovators risk being shunned as deviants until there is a critical mass of early adopters" (Centola & Macy, 2007, 708), effectively blocking the transmission of new ideas. Normatively laden beliefs and behaviors thus require complex contagion to spread because the threshold for change is overcome only when there is social reinforcement from multiple sources (Centola, 2018, 37).

Brokerage refers to a phenomenon in which an actor connects otherwise disconnected parts of a network. It is often thought that brokerage is conducive to the diffusion of novel ideas because an old idea in one group is potentially a new idea in another group. Brokering ties are "weak" in the sense that these connections between actors are often infrequent and non-transitive (i.e., friends of friends are not connected with each other). Granovetter (1973) famously argued that such ties can in fact be "strong," because they make the diffusion of information possible. However, Centola and Macy (2007, 709) pointed out that "when activation requires confirmation or reinforcement from two or more sources, the transitive structure that was redundant for the spread of information now becomes an essential pathway for diffusion." This means that although network structures of brokerage can introduce novel information into networks, social influence often requires confirmation from multiple sources.

Complex contagions have been studied, for example, in the context of behaviors driven by online sharing (Sprague & House, 2017) and political echo chambers (Boutyline & Willer, 2017). As far as we are aware, the idea of complex contagions has never been tested in the context of policy learning despite the increasing attention paid by public policy

scholars to policy learning in general (e.g., Heikkila & Gerlak, 2013) and to networks specifically as a potential source of policy learning (Henry et al., 2020).

Centola and Macy (2007) originally conceptualized complex contagion as having to do with multiple contacts. Centola (2018, 50) later added the insight that a fraction of contacts can be more important than their actual number in some contexts. In the context of belief change, this means that change may not take place if only a small fraction of social contacts "pulls" in the direction of belief change. Consider a case where someone has ten connections, and three of these contacts differ in their beliefs from the actor. In Centola and Macy's original view, this would count as a possible scenario for complex contagion because more than one contact socially "reinforces" belief change. However, there are still seven contacts that reinforce the actor's existing beliefs. Now compare this scenario to a situation where again three contacts have different beliefs from the actor, but the total number of contacts is only five. The number of ties to contacts with different beliefs remains the same as in the first case, but the social pressure is likely stronger because the contacts with different beliefs now constitute the majority. We thus expect that the share, not the absolute number of social ties, is what often matters for policy learning. In what follows, policy learning is conceptualized as increasing belief congruence according to the ACF model (Henry et al., 2020). This brings us to our first hypothesis:

H1: A higher share of social contacts holding beliefs that differ from the actor's beliefs make belief change more likely.

The theory of complex contagion is first and foremost a general theory of the network effects on belief and behavior change. However, we argue that there are also attribute-related factors that may make belief change more likely. A recurring finding in social network analysis is that of homophily where similarity attracts and, in time, leads to more similarity (McPherson et al., 2001). People and organizations do not only form ties with those who are similar to themselves, but they also tend to see similar social contacts as reliable sources of new information. Such homophily effects are also known to be common in the context of policy learning (Riche et al., 2020). Therefore, it is likely that policy actors are more attentive to the opinions and beliefs of actors they see as similar with themselves. Thus, we posit the following hypothesis:

H2: Similar kinds of actors are more likely to influence belief change.

Previous research has argued that public authorities often play important roles in policy subsystems due to their official decision-making power (Fischer et al., 2017). Ideally, public authorities can facilitate collaboration among actors with different beliefs and resources (Gronow et al., 2020). Therefore, we expect that governmental actors they are more likely to induce belief change than others (perhaps especially in one of our case countries, one-party Vietnam):

H3: Governmental actors are more likely to influence belief change.

Social network analysts have found that central actors often play key roles in diffusion processes because they have many contacts and therefore hold the potential to diffuse their beliefs among other actors (Borgatti, 2005). In addition, actors that are perceived to be influential by others are also likely to have a bigger effect on others' beliefs (Fischer & Sciarini, 2015) because their status is high (Centola, 2018, 48). These actors hold what is

known as reputational power (cf. Hunter, 1953). Therefore, it is likely that central actors and those that are seen as influential by their peers are more likely to induce belief change:

H4: Central actors are more likely to influence belief change.

H5: Influential actors are more likely to influence belief change.

Network analyses have repeatedly found that reciprocal relationships are important in all social networks because social actors in general, policy actors included, tend to reciprocate social ties (Gouldner, 1960). Reciprocal relationships are also likely to be sources of trust and social capital (Berardo & Scholz, 2010). In the context of our study, reciprocity takes place when policy actors A and B mutually collaborate with each other. We expect that reciprocal relationships are more likely to influence belief change than other relationships:

H6: Reciprocal relationships are more likely to influence belief change than non-reciprocal ones.

Case selection, data, and methods

Gerlak et al. (2018, 336) argue that environmental policies are fertile ground for studying policy learning because "they are characterized by high levels of uncertainty associated with cross-scale feedbacks, unclear problem definition and resolution, and diverse policy interests". This characterization applies to the cases we selected: the REDD+ policy subsystems in Vietnam, Indonesia, and Brazil. REDD+ was established at the 13th UNFCCC Conference of the Parties (COP) in 2007 in Bali, Indonesia. It was introduced as a market-based global climate policy initiative aiming at halting forest loss and related $CO2$ emissions in forest-rich tropical countries (Stern, 2006). Initially negotiated as RED, with a focus on deforestation, forest degradation was later added as a second D, followed by conservation, sustainable management of forests, and enhancement of forest carbon stocks (indicated by the plus sign). As other anti-deforestation and forest-based mitigation approaches (Bäckstrand & Lövbrand, 2006), REDD+ faces many uncertainties. Some sources of uncertainty are related to the actual and long-term impact of REDD+ mitigation efforts, expressed in additionality and permanence of emission reductions from reduced deforestation, and in leakage, which happens when measures aimed at one area lead to deforestation elsewhere. With diverse policy interests at play, forests and forested land in the tropics are subject to a multitude of pressures from cross-level interactions among global, national and local policy actors (Brockhaus et al., 2014). Since its inceptions, REDD+ has triggered policy changes in countries' domestic arena, especially in the land use and forest sectors, even though the effectiveness and fairness of the mechanism remains contested (Korhonen-Kurki et al., 2019).

Most policy research focuses on mature subsystems where one can easily identify the key participants, the substantive topics, and the territorial boundary of the subsystem (Ingold et al., 2017). However, "by focusing only on mature subsystems, we miss an important piece of the puzzle: we do not know how and why particular subsystems form" (ibid. 2). Thus, Ingold et al. (2017) called for more research to focus on nascent subsystems that are not yet mature. REDD+ is such an emerging subsystem, just over a decade old and evolving over time (Brockhaus et al., 2014; Korhonen-Kurki et al., 2019). It is possible that belief change is likelier in nascent subsystems than in mature subsystems. Actors may not yet have permanent policy beliefs and, therefore, are more likely to change

their beliefs because the topic of the subsystem is relatively new and still in the process of being formed. This means that policy actors scan their social environment and update their beliefs based on social influence. It is therefore possible that belief change in general, and also due to social influence, is likelier in nascent than in mature subsystems. This makes nascent subsystems a good candidate for doing research on policy learning, as actors are in general more likely to change their beliefs. However, this also means that we cannot be entirely certain that our results would apply in mature settings.

Next, we discuss the data and methods in more detail.

Case selection

According to Ingold et al. (2019), an ideal research design for assessing policy learning would involve a panel study of the same actors over two periods of time. Our design fulfills this criterion as it is a panel study where we follow the same actors over time. The data in this study come from two rounds of national-level policy network surveys of the REDD+ subsystem (Brockhaus et al., 2014). The case countries are Brazil, Indonesia, and Vietnam. Countries were purposefully selected based on their relevance for and early engagement with REDD (e.g., through engagement in the Forest Carbon Partnership Facility), and due to the presence of pilot projects. Comparison across cases can be facilitated by the presence of contextual differences (Berg-Schlosser & De Meur, 2009), which in the selected countries range from diverse regime structures, governance frameworks, and institutions to earlier, established climate and forest policies. In Brazil, REDD+ has been a contentious issue from the very start, with stronger polarization of opinions than elsewhere, including factions with opposite ideas about embracing carbon offsetting and of protecting the rights of indigenous people. In Vietnam, REDD+ started as a concerted policy effort of a unitary authoritarian regime supported by international donors with virtually no space for any kind of open dissent. In Indonesia, the emerging policy domain was initially driven by high-level multilateral and bilateral (Norway) partnerships and by support from segments of civil society but with domestic power struggles within the Indonesian bureaucracy. (Angelsen & McNeill, 2012; Brockhaus & Di Gregorio, 2014; Brockhaus et al., 2014, 2017; Korhonen-Kurki et al., 2014, 2019.)

Vietnam is an interesting case for political research because the country is a single-party socialist republic. In a non-democratic country, it can be difficult to get people to voice their actual opinions. Furthermore, it is possible that people take their cues from government actors and try to follow the official party doctrine. We think that these reasons make Vietnam an interesting litmus test for the idea of complex contagions. In a single-party state, it is reasonable to assume that the opinions of those in power are more important than the opinions of one's contacts. In this context, it is possible that no evidence for the local network effects that complex contagion should produce is found, unless, of course, those in power are those to whom people are also connected. However, if complex contagion is witnessed even in a case like Vietnam, this is powerful evidence for the idea because it confirms that complex contagion can take place even in authoritarian countries where people tend to follow "official" opinions. Vietnam is thus a least likely case where we would not expect general social influence to play a role in policy learning. The value of least likely cases is that if the theory is supported by the data, it is powerful evidence for the validity of the theory (Levy, 2008, 12).

Data

In the first round of data collection, survey responses were collected from 55 policy actors in Brazil (response rate 86%), 65 in Indonesia (response rate 64%), and 52 in Vietnam (response rate of 100%), and in the second round, 72 in Brazil (55%), 84 in Indonesia (64%), and 48 in Vietnam (87%). The respondents were high-level representatives of organizations that were involved or had relevance in the national REDD+ policy subsystem. The first round of data collection was conducted between 2010 and 2012 and the second round between 2015 and 2016. For the temporal analyses, we included only organizations that participated in both rounds, leaving us with 27 responses in Brazil, 43 in Indonesia, and 27 in Vietnam. However, when constructing the independent variables representing organizational attitudes in the first round of data collection, we used the whole dataset from the first round. Due to the temporal nature of the study data, we are able to assess the role of policy learning.

Studying the effect that social ties have on policy learning thus requires temporal data, which is probably one of the reasons why so little research on social influence in this context exists. Previous researchers often relied on respondents' own assessments of whether learning has taken place (Leach et al., 2013). However, the problem with this measure is that it is possible that some people are more willing to admit that learning has taken place than others. For example, respondents with technical and scientific competence might be less willing to do so (Leach et al., 2013, 612). Instead of relying on respondents' recall, we measure the changes taking place at the level of the policy actors' beliefs.

Dependent variable

The dependent variable measures changes in REDD+ policy beliefs between two data collection rounds. The respondents were asked about their level of agreement or disagreement with several opinion statements related to REDD+ using a five-point Likert scale (1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, 5 = Strongly agree). We performed a factor analysis using all questions we identified as policy core beliefs (more on this issue below). Based on the results of the factor analysis, we focused our analysis on four opinion statements that were asked in both rounds on four crucial outcomes of REDD+ related to Effectiveness, Efficiency, and Equity (also known as the 3 E's; Angelsen et al., 2009), and to governance outcomes. Together, these statements measure how the organization assesses REDD+ as a policy instrument. Cronbach's alpha for these four questions was 0.723 in the first round data and 0.707 in the second round. Using only three questions instead of four in the second round would make the Cronbach alpha slightly better (0.714), but the difference is small, and it would mean that one question would have to be omitted from the first round of analysis for the sake of comparability. Therefore, we decided to base the composite variable on four questions. For the composite variable, we computed the mean of these variables for each respondent in both rounds. The content of the four statements remained the same across the two rounds, although the wording was slightly amended based on feedback pointing to the need to simplify and shorten the statements and to reflect the evolution of particular positions and language in the subsystem (see Table 1).

Table 1 Statements for the Composite Variable

Round 1	Round 2
REDD is an effective option for reducing greenhouse gas emissions globally	REDD+ is an effective option for reducing greenhouse gas emissions globally
REDD is a financially affordable way to mitigate climate change	REDD+ is a financially affordable way to mitigate climate change
REDD will assure fairness in the international distribution of environmental costs and benefits	REDD+ is an equitable mechanism for balancing the burdens of climate change
REDD schemes will provide incentives and resources to improve forest governance (e.g., illegal logging and rule of law)	REDD+ leads to improved forest governance (e.g., illegal logging, access to justice, and rule of law)

These questions reflect underlying policy beliefs because they all assessed the viability of REDD+. The ACF distinguishes beliefs into three types: deep core, policy core, and secondary beliefs (Weible & Sabatier, 2009). Deep core refers to broad and stable normative beliefs, such as general liberal and conservative outlooks. Policy core beliefs span the subsystem in question and are usually the ideational basis for advocacy coalitions, whereas secondary beliefs are narrower and relate to a part of the subsystem. For example, a broad belief concerning the viability of REDD+ in tackling deforestation would constitute a policy core belief, and a belief concerning a specific technical policy solution would count as a secondary belief. The beliefs that we focus on would be considered policy core beliefs in the ACF sense of the term because they are normative beliefs that relate to the topic of the subsystem (i.e., the REDD+ program).

The dependent variable in the analyses was actor's belief changes in the composite variable between rounds. The value of the composite variable in round one was subtracted from the value of the composite variable in the second round. The resulting dependent variable was approximately normally distributed, and the values ranged from −1.75 to + 1.50. A positive value of the change variable indicates a positive change in how the organization assesses REDD+ as a policy instrument, and a negative value indicates a negative change. Previous researchers have tended to rely on respondents' own assessments of whether policy learning has taken place (Leach et al., 2013). However, it is possible that respondents have recall problems, and they might not even be able to consciously assess the extent of their learning. Our measure for policy learning does not suffer from these problems.

Independent variables

To measure the network connections between the organizations in our sample, the respondents were presented with a roster of the organizations that were part of the national REDD+ policy subsystems, and they were asked *"With which organizations does [your organization] regularly collaborate concerning REDD+ related issues?"*. A collaboration network was constructed on the basis of this question. Because we are interested in analyzing the effect that other people's beliefs have on an actor's beliefs, we calculated how many of an actor's contacts in the collaboration network were more negative and more positive than the actor in their attitude toward REDD+ in the first round of data collection. In what follows, we often refer to the contacts that an actor has as *alters* and the actor itself as *ego*, as is common in network analysis.

To test Hypothesis 1, we calculated our main independent variable, the overall ratio of more negative versus more positive contacts or collaboration partners. For example, if an actor had three contacts that had more negative beliefs about REDD+, and one contact with more positive beliefs, then the overall ratio would be -2 $(-3+1)$.[1] In constructing this variable, we considered only ties that the respondents themselves reported (i.e., outgoing ties in network parlance) because we think that only actors that the respondents considered to be collaborators would be likely to influence their beliefs. Thus, cases in which only the contacts report a collaboration tie were excluded.

To test Hypotheses 2–5, we calculated the ratio of more negative and more positive alters among different actor groups. Hypothesis 2 states that political actors are more attentive to the opinions and beliefs of organizations that are of the same type. According to this logic, for example, a non-governmental actor (NGO) would be more likely to influence other NGOs than different kinds of organizations. Organization type categories include government organizations, domestic environmental NGOs, domestic NGOs with other interests, foreign government agencies, intergovernmental organizations, international businesses, international environmental NGOs and networks, international NGOs (non-environmental), international research institutes, national business organizations, and national research institutes. In addition, we postulated that government actors are more influential than others (H3), perhaps especially in Vietnam, and we tested whether they were more important than others in triggering belief change by focusing only on collaboration links to governmental organizations. The effect of central actors (H4) was tested by counting in-degree centrality in the collaboration network. In-degree measures the incoming collaboration ties for each actor. The respondents were also asked to "indicate those organizations that stand out as especially influential on domestic REDD policies". The effect of influential actors (H5) was analyzed by focusing on ties to organizations among the most influential quintile. To test Hypothesis 6, we focused only on reciprocal collaboration ties (acknowledged by both the actors themselves and their contacts).

Table 2 presents the dependent variable, the six independent variables used to test our hypotheses (H1-H6), their measurement, and survey items used to construct them.

Methods

For the analysis, we used a node-level regression in UCINET. Node-level regression in UCINET calculates the coefficients using a standard OLS linear regression, but estimates standard errors with a simulation. This method thus takes into account that observations in networks are not independent of each other (Borgatti et al., 2013).

We present eleven different models for each country, all modeling the change in policy actors' beliefs about REDD+. Due to strong multicollinearity, the independent variables were added to the models one by one (models 1–6), and then with the main independent variable, which measured the overall share of outgoing ties with contacts that were different from the actor's beliefs (models 7–11). A limitation of our approach is that we could not control for all possible sources of belief change. In principle, it is possible that all actors whose belief change seems to have been affected by their contacts' beliefs were

---

[1] As robustness checks, we constructed the independent variables in varied ways. We used the share of more negative and more positive contacts, and the absolute number of more negative and more positive contacts separately, resulting in four different independent variables for the main independent variable alone. All robustness checks pointed toward the results presented in this paper. For the sake of simplicity, we present only the measure that combines the number of more negative and more positive contacts.

Table 2 Variables used in the analyses

Variable	Label	Measurement	Survey items used
Change (Dependent variable)	Change in beliefs about REDD+	Value of the composite variable measuring beliefs about REDD+ in round one, subtracted from the value of the same composite variable in round two	*Composite variable:* see Table 1 for survey items
Ratio of all alters (H1)	Ratio of all negative and positive alters	Number of alters that have a smaller value of the composite variable (beliefs about REDD+) compared to the actor subtracted from the number of alters that have a larger value of the same composite variable on round one	*Composite variable:* see Table 1 *Collaboration network:* "With which organizations does [your organization] regularly collaborate concerning REDD-related issues?"
Ratio of same organization type (H2)	Ratio of negative and positive alters with same organization type	Number of alters that are the same organization type as the actor, and have a smaller value of the composite variable (beliefs about REDD+) compared to the ego subtracted from the number of alters that are the same organization type as the actor, and have a larger value of the composite variable on round one	*Composite variable:* see Table 1 *Collaboration network:* "With which organizations does [your organization] regularly collaborate concerning REDD-related issues?" *Organization type:* different organization types
Ratio of governmental organizations (H3)	Ratio of negative and positive alters that are governmental organizations	Number of alters that are governmental organizations, and have a smaller value of the composite variable (beliefs about REDD+) compared to the actor subtracted from the number of alters that are governmental organizations, and have a larger value of the composite variable on round one	*Composite variable:* see Table 1 *Collaboration network:* "With which organizations does [your organization] regularly collaborate concerning REDD-related issues?" *Organization type:* "Governmental organization"

Table 2 (continued)

Variable	Label	Measurement	Survey items used
Ratio of central alters (H4)	Ratio of negative and positive alters that are among the most central	Number of alters that are among the most central quintile in the collaboration network, and have a smaller value of the composite variable (beliefs about REDD+) compared to the actor subtracted from the number of alters that are among the most central quintile in the collaboration network, and have a larger value of the composite variable on round one	*Composite variable:* see Table 1 *Collaboration network:* "With which organizations does [your organization] regularly collaborate concerning REDD-related issues?"
Ratio of influential alters (H5)	Ratio of negative and positive alters that are among the most influential	Number of alters that are among the most influential quintile in the influence network, and have a smaller value of the composite variable (beliefs about REDD+) compared to the actor subtracted from the number of alters that are among the most influential quintile in the influence network, and have a larger value of the composite variable on round one	*Composite variable:* see Table 1 *Collaboration network:* "With which organizations does [your organization] regularly collaborate concerning REDD-related issues?" *Influence network:* "Please indicate those organizations that stand out as especially influential on domestic REDD policies"
Ratio of reciprocal alters (H6)	Ratio of negative and positive reciprocal alters	Number of alters that are in a reciprocal collaboration relationship with the actor, and have a smaller value of the composite variable (beliefs about REDD+) compared to the actor subtracted from the number of alters that are in a reciprocal collaboration relationship with the actor, and have a larger value of the same composite variable on round one	*Composite variable:* see Table 1 *Collaboration network:* "With which organizations does [your organization] regularly collaborate concerning REDD-related issues?"

reacting to some exogenous event. This would mean that actors would change their beliefs and do it irrespective of their social contacts, even though their beliefs would now fall better in line with the beliefs of their contacts.

It is a general problem for all policy learning research that a perfect experimental design where all possible stimuli of learning would be accounted for is not possible (Ingold et al., 2019). However, it is unlikely that the beliefs of social contacts would not play any role if changes happen in both directions, more positive and more negative, and in correlation with the share of social contacts that hold these beliefs. Thus, if some exogenous event would explain changes in beliefs, it would be unlikely to correlate with the share of social contacts holding different beliefs. Another limitation is that not all respondents of the first survey round responded to the second survey. However, the group of organizations that either had ceased to exist or refused to participate in the second-round survey was not biased in the sense of representing a certain subset of the total population (for example, only NGOs).

Results

First, we look at the collaboration networks and how actors changed their beliefs between rounds of data collection in each country. Figures 1, 2, and 3 present the collaboration networks in Indonesia, Vietnam, and Brazil, respectively. The color of the actors (i.e., the nodes) represents the change in beliefs between data collection rounds. Red actors changed their beliefs on REDD+ to a more negative direction and green actors to a more positive direction between data collection rounds. Furthermore, the bigger the node, the more the beliefs changed. Actors that did not change their beliefs between rounds are marked blue, and actors that were present only in the first round of data collection are marked gray. The colors of the links between actors represent the beliefs of the alters on round 1 relative to the beliefs of the actor (i.e., ego), and the arrowhead indicates the direction of social influence. Red links with the arrowhead directed at an actor show that alters' beliefs regarding REDD+ were more negative compared to the beliefs of the actor, green links indicate a more positive alter, and blue links indicate an alter with similar beliefs as the actor.

In Fig. 1, for example, the national research institute (RES) at the top of the figure is marked green, indicating a positive belief change, and the two green links with arrowheads pointing toward this institute show two contacts that were more positive regarding REDD+ on round 1 compared to this actor. The two red links without arrowheads indicate that the organization in question itself was more negative regarding REDD+ on round 1 compared to two actors it is linked with. The actor labels show the organization type, all explained in the legends of the figures.

From these figures, we can see that in all of our case countries, some of the organizations changed their beliefs. Furthermore, the figures indicate that social influence might be taking place. Next we turn to statistical analyses to find out whether this is the case.

To begin with descriptive statistics, we can see that belief changes are not exclusively occurring in any particular kinds of organizations. Rather, organizations in several categories (NGO, business, government, etc.) change their beliefs and this happens in both negative and positive directions in all case countries. Furthermore, there were no statistically significant differences in the mean belief change between the countries (ANOVA $F = 0.762$, $p = 0.47$). As a single-party regime, Vietnam deserves special attention. If all actors followed the official government line in Vietnam, we would find everyone changing
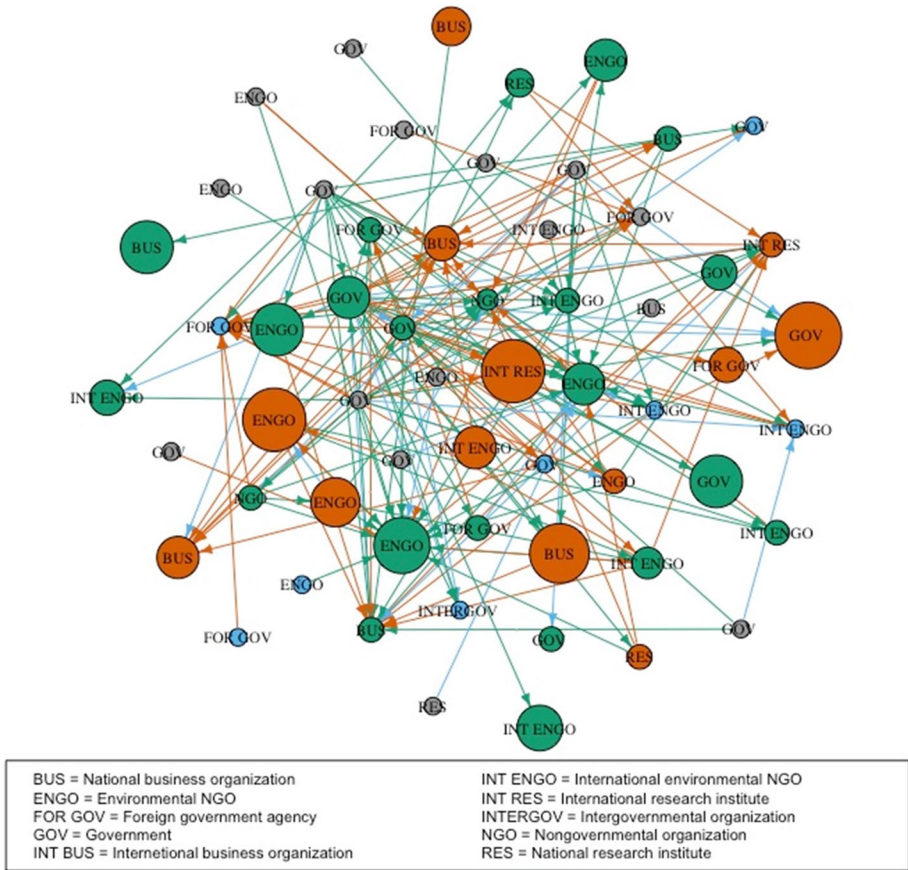
BUS = National business organization
ENGO = Environmental NGO
FOR GOV = Foreign government agency
GOV = Government
INT BUS = Internetional business organization

INT ENGO = International environmental NGO
INT RES = International research institute
INTERGOV = Intergovernmental organization
NGO = Nongovernmental organization
RES = National research institute

Fig. 1 Belief change in the Indonesian network

their beliefs in line with those of the government. However, this is not the case, which is an indication that policy actors and their beliefs are, to some degree, independent from the official government position.

To test our six hypotheses, we used node-level regressions. The regression coefficients of the node-level regression models are presented in Figs. 4 and 5, and the full models in Appendix Tables 4, 5, and 6.

Our main hypothesis on complex contagion (H1) stated that a higher share of social contacts holding beliefs that differ from the actor's beliefs would make belief change more likely. The results confirm this hypothesis for Indonesia and Vietnam, as shown in Fig. 4. The bigger the share of social contacts that hold different beliefs about REDD+, the more likely that the actor's beliefs change. This finding holds for both more positive and more negative contacts. Thus, contacts that hold more negative beliefs about REDD+ than the actor influence belief change in this direction and contacts with more positive beliefs in a more positive direction. We did not, however, find this complex contagion effect in Brazil. In models 7 to 11, we tested for all countries whether the beliefs of different kinds of alters—actors of the same organization type (H2), governmental actors (H3), central actors (H4), influential actors (H5) or actors with reciprocal ties (H6)—have an effect on the
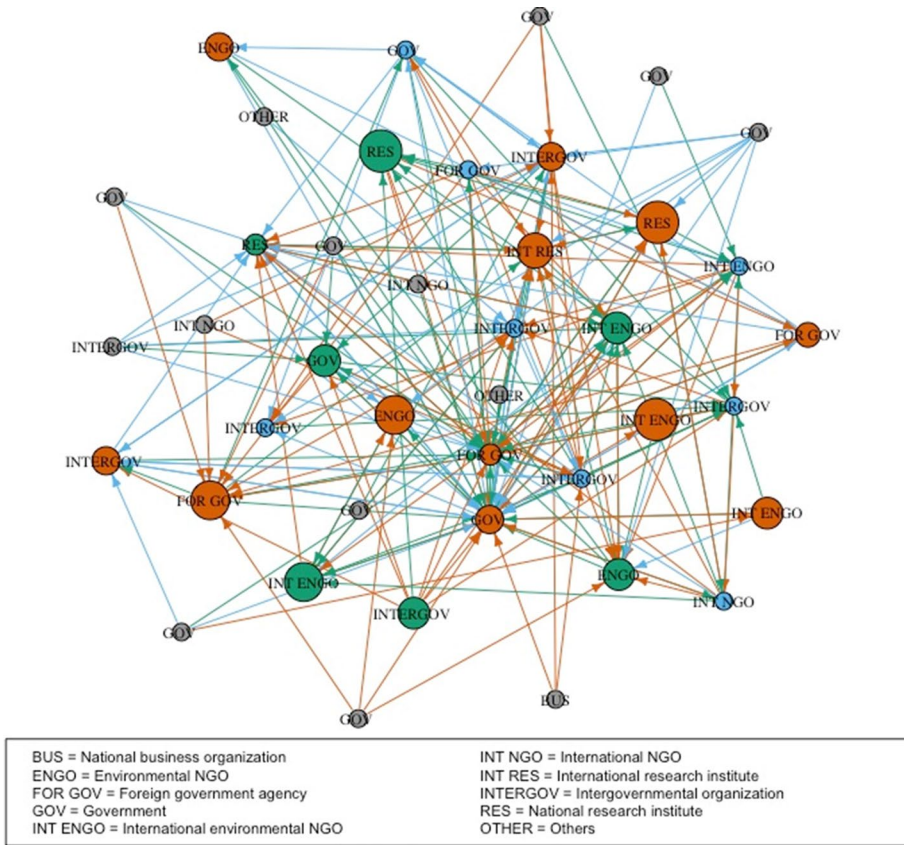
BUS = National business organization
ENGO = Environmental NGO
FOR GOV = Foreign government agency
GOV = Government
INT ENGO = International environmental NGO

INT NGO = International NGO
INT RES = International research institute
INTERGOV = Intergovernmental organization
RES = National research institute
OTHER = Others

Fig. 2 Belief change in the Vietnamese network

actors' belief change over the effect of all alters combined (H1). Results presented in Fig. 5 show that this is not the case. Next, we discuss the model results in more detail by country.

In Indonesia, all independent variables are statistically significant when added to the model individually (Fig. 4, see also the regression tables in the Appendix). Beliefs of the actor's contacts in general have an effect on belief change (as H1 expects), but the effect is bigger when only contacts representing the same organization type as the actor are taken into account (as indicated by H2) or when only reciprocal ties are considered (H6). Beliefs of governmental alters (H3), central alters (H4), and influential alters (H5) also have an effect but it is not bigger than the effect of all alters combined. The parameter estimate is the highest for reciprocal alters (model 6), but the model fit is not as high as that of the other models. This result is likely due to the very low reciprocity of the network as only seven pairs of organizations reported reciprocal ties. The second highest parameter estimate is for actors of the same organizational type (model 2), but the model fit among the models containing only one independent variable is the highest for all actors (model 1). The highest adjusted R^2 among all models is for the model combining these two (model 6). The estimates are statistically significant in this model for all actors and also for actors of the same organization type (e.g., NGOs being influenced by other NGOs). Thus, in addition to the effect of the beliefs
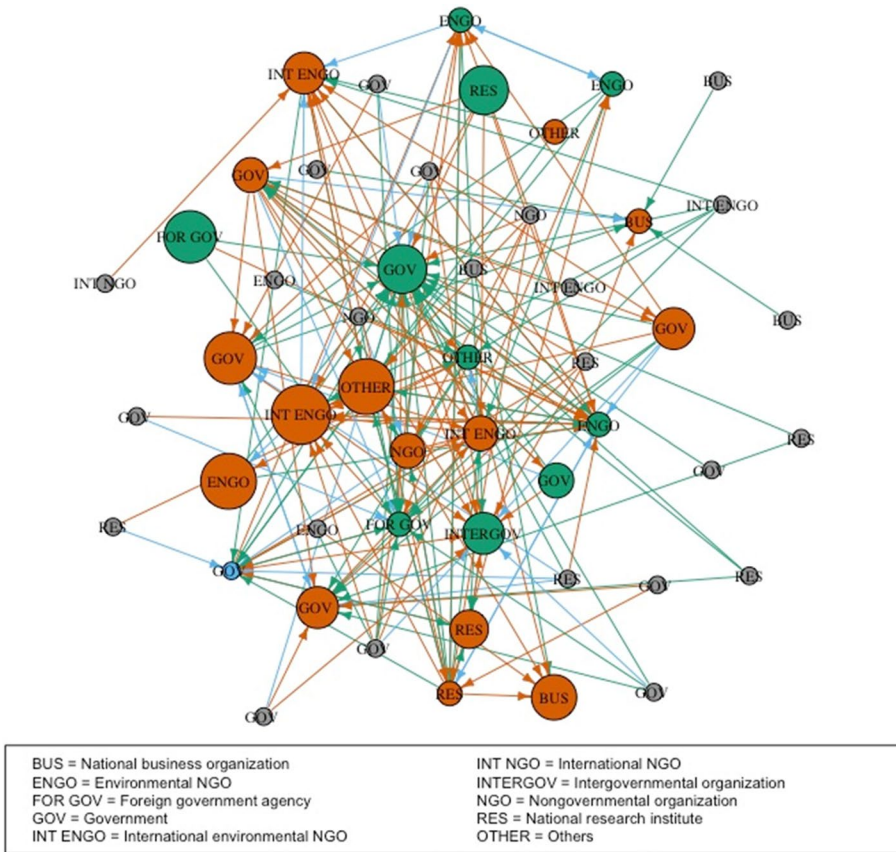
BUS = National business organization
ENGO = Environmental NGO
FOR GOV = Foreign government agency
GOV = Government
INT ENGO = International environmental NGO

INT NGO = International NGO
INTERGOV = Intergovernmental organization
NGO = Nongovernmental organization
RES = National research institute
OTHER = Others

Fig. 3 Belief change in the Brazilian network

of all contacts, the beliefs of similar organizations have an additional effect, perhaps because similar organizations are seen as more credible as sources of social influence.

In Vietnam, the beliefs of all contacts (i.e., their share, H1) but also central (H4), influential (H5), and reciprocal (H6) contacts are statistically significant when added to the model individually. The adjusted R^2 is highest in model 6 (0.263), indicating that the beliefs of reciprocal contacts explain the variation in the dependent variable the best, although alters' influence and centrality also have an effect. Thus, the share of social contacts holding different beliefs is not the only thing that matters in explaining belief change. In the case of Vietnam it could be that governmental contacts would be solely responsible for initiating belief change but this is not the case. Government organizations' beliefs do not have an effect on belief change (and neither are the most influential actors are solely government actors, either).

Brazil differs from Indonesia and Vietnam in that none of the independent variables have a statistically significant effect on the way organizations change their beliefs about REDD+. Thus, none of our hypotheses get support in Brazil.
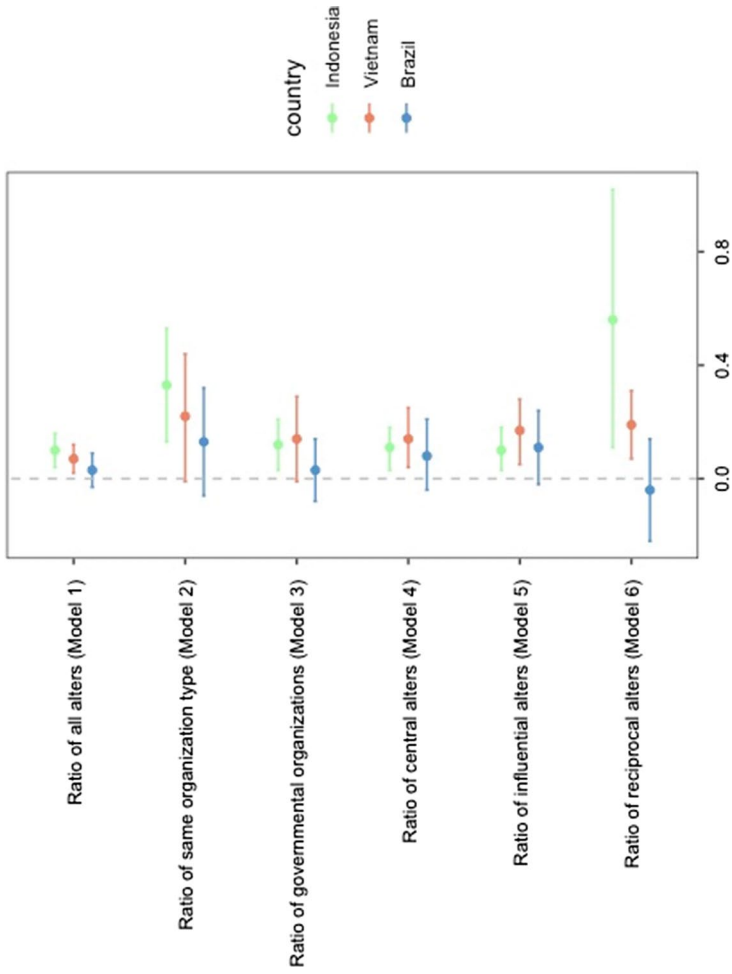
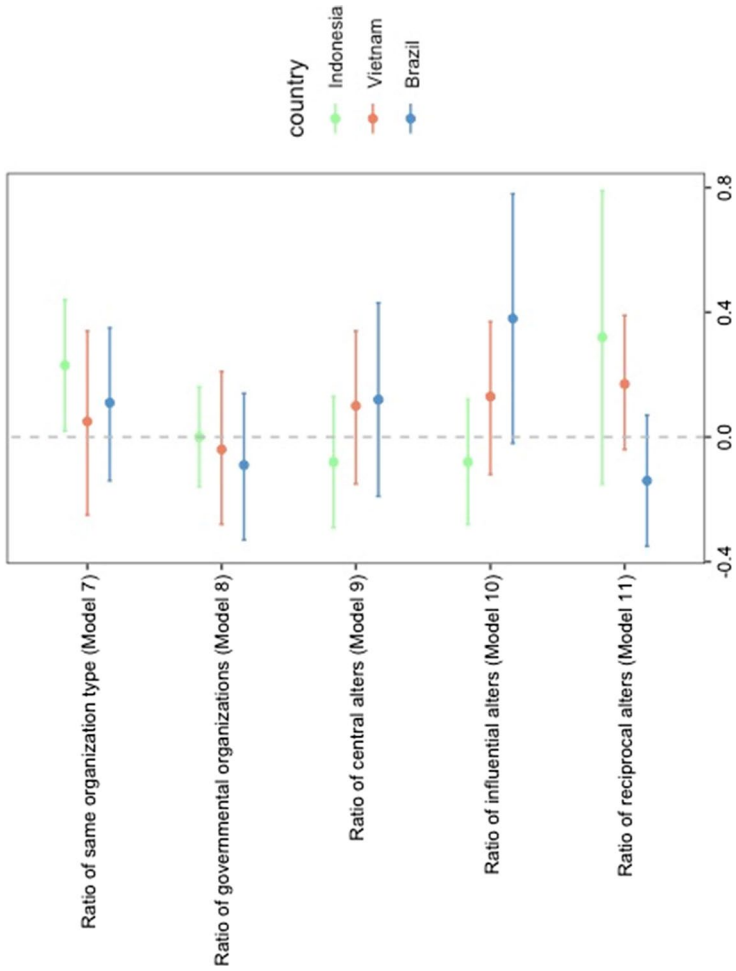**Fig. 4** Regression coefficients for models 1–6

Fig. 5 Regression coefficients for models 7–11

Discussion and conclusions

One of the promises of studying policy learning is that it can act as a source of policy change. If policy learning alters the perceptions of the seriousness and causes of policy problems, it may have an effect on the perceived need to address these problems (Weible et al., 2016, 10). Furthermore, learning can converge policy beliefs, build consensus (Leach et al., 2013), and potentially develop a comprehensive understanding of the issues involved. Even if no consensus develops, policy learning can alter coalition dynamics since changes in policy beliefs may lead to new advocacy coalition formations. We set out to study policy learning by focusing on the role that the network mechanism of social influence plays. We asked whether the beliefs of a policy actor's social contacts have an effect on how that actor's beliefs change over time—whether policy learning takes place. Existing network research and research on advocacy coalitions have mostly focused on the opposite mechanism, social selection, by showing that the beliefs of policy actors are associated with their selection of collaboration partners. Previous researchers of policy learning have proposed that network structure might affect policy learning (Newig et al. 2010) but either have not measured what these effects are or have measured them in a way that does not account for actual links between organizations (Henry et al., 2020).

We argued that when changes in policy beliefs result from social influence, this happens through complex contagion (Centola & Macy, 2007), a process by which reinforcement from multiple social sources acts as a catalyst for change. The results support the idea that policy learning, operationalized as belief change, takes place as a result of complex contagion. In Vietnam and Indonesia, we found that the bigger the share of social contacts who have policy beliefs that are different from the actor's beliefs, the more likely that an actor's opinion will change. In Brazil, however, there was no such effect.

Of the case countries, the REDD+ policy subsystem in Vietnam is smaller and largely collaborative, in Indonesia it is larger and more diverse but predominantly collaborative, while in Brazil it is the most conflictual (Brockhaus & Di Gregorio, 2014). In addition, anti-deforestation policies have existed longer in Brazil, and carbon offsetting through forest management is also more established there (Nepstad et al., 2014). This means that the REDD+ policy subsystem was built on a well-established base, and thus, the policy subsystem may not be nascent in the same way as in Indonesia and Vietnam. Policy beliefs in established subsystems are less likely to change than in nascent ones, where conflict lines between opposing coalitions are weaker (Ingold et al., 2017). Thus, although the REDD+ subsystem is nascent in Brazil, it is linked to existing and strongly ideological and polarized debates about forest carbon offsetting, anti-deforestation approaches, and land use across actors and levels of governance (Gebara et al., 2017). In Indonesia, the policy domain has been less conflictual as debates in the early years of REDD+ were dominated by positive views, with some contention about reconciling economic and environmental protection, but dominant policy actors portraying reconciliatory win–win solutions (Cronin et al., 2016). In Vietnam, the government was keen to embrace opportunities to engage with markets for environmental services (Thuy et al., 2008). Strong conflicts were not and could not be present as open dissent with the government is not tolerated (Pham et al., 2014).

We suspect that the adversarial nature of the Brazilian subsystem makes policy actors immune to policy learning. This suspicion is supported by Weible and Sabatier (2009), who argued that policy learning is more likely to occur in collaborative compared to adversarial subsystems because collaborative cases are associated with moderate rather than extreme

beliefs and with less polarization. While Weible and Sabatier (2009) discuss policy learning in general, our study confirms this presupposition in the case of social influence as a driver of policy learning. This tension between collaboration and polarization indicates a practical implication for efforts to halt deforestation in Brazil. If the polarization of beliefs and high level of conflict is not tackled, policy learning through complex contagion probably will not influence policy processes. In addition, if polarization in Brazil persists, it is likely that future policy change might be abrupt and driven by major changes in external factors, as opposed to incremental policy learning processes (Sabatier & Jenkins-Smith, 1993) that result from network mechanisms.

Our main finding thus is that complex contagion is a mechanism that explains how social influence takes place in the context of policy learning. However, we also showed that context-dependent factors having to do with the attributes of actors are also at play. In Indonesia, we found an organizational homophily effect, meaning that organizations are more likely to change their beliefs in response to social influence from similar organizations. This result is in line with previous studies (Gallemore et al., 2015; Moeliono et al., 2014). We also found that actors are more likely to be influenced by actors perceived as influential, thus showing that higher-status actors are more important than others (cf. Centola, 2018, 48). In more practical terms, this would imply that policy learning in Indonesia might lead to increased consensus around the beliefs of dominant actors. Many of these influential actors have been very cautious about accelerating anti-deforestation action.

The overall implication of our study for theories of policy learning and for the ACF is that learning can occur by linked actors becoming more similar to each other in their beliefs (cf. Henry et al., 2020). It remains for future research to find out what the implication of the mechanisms of social influence and complex contagion is for overall coalition dynamics. As a preliminary hypothesis, we present the idea that coalition lines can become blurred as a result of complex contagion as actors' beliefs become more congruent (cf. Henry et al., 2020). Furthermore, if a network is dense, complex contagion can make the diffusion of policy beliefs happen quickly. However, on the occasion that complex contagion also occurs in adversarial contexts, belief congruence among linked actors is likely to make the polarization of coalitions more intense. We hope future research tests these preliminary suggestions.

We suppose that policy learning and therefore also social influence are likely to play a role, especially in nascent subsystems, but as we did not have data on mature subsystems, we could not systematically control for the effect of nascent versus mature subsystems. Therefore, future studies should try to test whether policy actors are less susceptible to social sources of policy learning in mature policy subsystems than in nascent ones. We are confident in arguing that collaborative subsystems are more susceptible to complex contagion than conflictual ones, which is a likely explanation for the lack of evidence of complex contagion in Brazil, the most adversarial and polarized of the cases. However, this is also a topic that calls for future researcher.

Another issue that merits attention in future research is disentangling the effects of social influence on different types of policy beliefs. We focused on a set of policy beliefs related to the viability of REDD+. We think these beliefs constitute the policy core of the REDD+ subsystem and policy core beliefs have been shown to be important for the formation of advocacy coalitions (Weible & Sabatier, 2009). Policy core beliefs are likely more susceptible to social influence than so-called deep core beliefs, which concern stable and very general policy-related worldviews. However, it is possible that secondary beliefs concerning technical solutions for realizing policy core beliefs are even more likely to change because of social influence if the ACF assertion that secondary beliefs are the easiest to

change is correct (Weible & Sabatier, 2009). This would mean that secondary beliefs also diffuse more easily through networks. Thus, systematically disentangling the relationship between different kinds of beliefs and social influence calls for future research.

Appendix: Correlation and regression tables

See Tables 3, 4, 5, and 6.

Table 3 Pearson correlations of variables used in the analyses

Indonesia	1	2	3	4	5	6
1 Change						
2 Ratio of all alters	0.456					
3 Ratio of same organization type	0.448	0.407				
4 Ratio of governmental organizations	0.381	0.841	0.283			
5 Ratio of central alters	0.391	0.935	0.314	0.923		
6 Ratio of influential alters	0.385	0.929	0.300	0.917	0.992	
7 Ratio of reciprocal alters	0.353	0.404	0.665	0.198	0.302	0.261
N	43	43	43	43	43	43
Vietnam	1	2	3	4	6	5
1 Change						
2 Ratio of all alters	0.468					
3 Ratio of same organization type	0.308	0.564				
4 Ratio of governmental organizations	0.356	0.823	0.484			
5 Ratio of central alters	0.484	0.906	0.642	0.706		
6 Ratio of influential alters	0.496	0.879	0.372	0.742	0.897	
7 Ratio of reciprocal alters	0.539	0.831	0.448	0.754	0.749	0.769
N	27	27	27	27	27	27
Brazil	1	2	3	4	6	5
1 Change						
2 Ratio of all alters	0.208					
3 Ratio of same organization type	0.265	0.626				
4 Ratio of governmental organizations	0.108	0.877	0.627			
5 Ratio of central alters	0.250	0.909	0.524	0.798		
6 Ratio of influential alters	0.307	0.949	0.598	0.780	0.927	
7 Ratio of reciprocal alters	0.083	0.577	0.063	0.439	0.561	0.535
N	27	27	27	27	27	27

Table 4 Parameter estimates and model fit for node-level regression models explaining change in beliefs about REDD+ in Indonesia

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Intercept	−0.000 (0.101)	−0.034 (0.103)	0.003 (0.105)	−0.004 (0.105)	−0.011 (0.106)	0.003 (0.107)
Ratio of all alters	0.097 (0.030)**					
Ratio of same organization type		0.328 (0.102)**				
Ratio of governmental organizations			0.119 (0.045)*			
Ratio of central alters				0.105 (0.039)*		
Ratio of influential alters					0.104 (0.039)*	
Ratio of reciprocal alters						0.563 (0.233)*
Model fit						
Adj. R^2	0.188	0.181	0.124	0.132	0.127	0.104
Prob>F	0.002	0.003	0.012	0.010	0.011	0.020

	Model 7	Model 8	Model 9	Model 10	Model 11
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Intercept	0.041 (0.099)	−0.000 (0.102)	0.009 (0.102)	0.015 (0.103)	−0.015 (0.101)
Ratio of all alters	0.069 (0.031)*	0.099 (0.056)	0.155 (0.084)	0.156 (0.081)	0.080 (0.302)*
Ratio of same organization type	0.229 (0.107)*				
Ratio of governmental organizations		−0.004 (0.082)			
Ratio of central alters			−0.078 (0.107)		
Ratio of influential alters				−0.081 (0.103)	
Ratio of reciprocal alters					0.322 (0.240)
Model fit					
Adj. R^2	0.253	0.168	0.179	0.181	0.204
Prob>F	0.001	0.009	0.007	0.007	0.004

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 5 Parameter estimates and model fit for node-level regression models explaining change in beliefs about REDD+ in Vietnam

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Intercept	−0.096 (0.118)	−0.093 (0.128)	−0.127 (0.125)	−0.074 (0.118)	−0.161 (0.117)	−0.103 (0.113)
Ratio of all alters	0.072 (0.027) *					
Ratio of same organization type		0.215 (0.113)				
Ratio of governmental organizations			0.140 (0.074)			
Ratio of central alters				0.144 (0.052) *		
Ratio of influential alters					0.169 (0.059) **	
Ratio of reciprocal alters						0.191 (0.060) **
Model fit						
Adj. R^2	0.188	0.059	0.092	0.203	0.215	0.263
Prob>F	0.014	0.118	0.069	0.011	0.009	0.004

	Model 7	Model 8	Model 9	Model 10	Model 11
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Intercept	−0.092 (0.121)	−0.090 (0.122)	−0.080 (0.121)	−0.143 (0.128)	−0.101 (0.115)
Ratio of all alters	0.067 (0.034)	0.084 (0.049)	0.026 (0.065)	0.022 (0.057)	0.010 (0.048)
Ratio of same organization type	0.045 (0.152)				
Ratio of governmental organizations		−0.036 (0.125)			
Ratio of central alters			0.099 (0.125)		
Ratio of influential alters				0.126 (0.126)	
Ratio of reciprocal alters					0.173 (0.110)
Model fit					
Adj. R^2	0.157	0.157	0.175	0.188	0.233
Prob>F	0.049	0.049	0.038	0.032	0.016

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 6 Parameter estimates and model fit for node-level regression models explaining change in beliefs about REDD+ in Brazil

	Model 1 B (SE)	Model 2 B (SE)	Model 3 B (SE)	Model 4 B (SE)	Model 5 B (SE)	Model 6 B (SE)
Intercept	-0.177 (0.152)	-0.222 (0.152)	-0.173 (0.157)	-0.145 (0.154)	-0.157 (0.149)	-0.197 (0.156)
Ratio of all alters	0.032 (0.030)					
Ratio of same organization type		0.130 (0.095)				
Ratio of governmental organizations			0.031 (0.058)			
Ratio of central alters				0.084 (0.065)		
Ratio of influential alters					0.106 (0.066)	
Ratio of reciprocal alters						-0.038 (0.091)
Model fit						
Adj. R^2	0.005	0.033	-0.028	0.025	0.058	-0.033
Prob>F	0.298	0.183	0.592	0.209	0.120	0.680

	Model 7 B (SE)	Model 8 B (SE)	Model 9 B (SE)	Model 10 B (SE)	Model 11 B (SE)
Intercept	-0.213 (0.158)	-0.208 (0.158)	-0.133 (0.165)	-0.119 (0.148)	-0.199 (0.151)
Ratio of all alters	0.011 (0.039)	0.076 (0.064)	-0.017 (0.073)	-0.130 (0.092)	0.059 (0.037)
Ratio of same organization type	0.108 (0.124)				
Ratio of governmental organizations		-0.094 (0.119)			
Ratio of central alters			0.117 (0.159)		
Ratio of influential alters				0.381 (0.205)	
Ratio of reciprocal alters					-0.138 (0.107)
Model fit					
Adj. R^2	-0.004	-0.011	-0.014	0.094	0.030
Prob>F	0.404	0.434	0.450	0.117	0.264

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

References

Angelsen, A., Brockhaus, M., Kanninen, M., Sills, E., Sunderlin, W. D., & Wertz-Kanounnikoff, S. (Eds.). (2009). *Realising REDD+: National strategy and policy options*. Center for International Forestry Research (CIFOR).

Angelsen, A. A., & D. McNeill. 2012. *The evolution of REDD+. Analysing REDD+*: *Challenges and choices.* Center for International Forestry Research (CIFOR), Bogor.

Bäckstrand, K., & Lövbrand, E. (2006). Planting trees to mitigate climate change: Contested discourses of ecological modernization, green governmentality and civic environmentalism. *Global Environmental Politics, 6*(1), 50–75.

Bakır, C. (2017). Policy learning and policy change: Learning from research citations. *Policy Sciences, 50*(4), 585–597.

Bennett, C. J., & Howlett, M. (1992). The lessons of learning: Reconciling theories of policy learning and policy change. *Policy Sciences, 25*(3), 275–294.

Berardo, R., & Scholz, J. T. (2010). Self-organizing policy networks: Risk, partner selection, and cooperation in estuaries. *American Journal of Political Science, 54*(3), 632–649.

Berg-Schlosser, D., & Meur, G. (2009). Comparative research design: case and variable selection. In B. In Rihoux & C. C. Ragin (Eds.), *Applied social research methods: Configurational comparative methods: Qualitative comparative analysis (QCA) and related techniques* (Vol. 51, pp. 19–32). SAGE. https://doi.org/10.4135/9781452226569.

Borgatti, S. P. (2005). Centrality and network flow. *Social Networks, 27*(1), 55–71.

Borgatti, S. P., Everett, M. G., & Johnson, J. C. (2013). *Analyzing social networks*. Sage.

Boushey, G. (2010). *Policy diffusion dynamics in America*. Cambridge University Press.

Boutyline, A., & Willer, R. (2017). The social structure of political echo chambers: Variation in ideological homophily in online networks. *Political Psychology, 38*(3), 551–569.

Brockhaus, M., & Di Gregorio, M. (2014). National REDD+ policy networks: From cooperation to conflict. *Ecology and Society, 19*(4), 14.

Brockhaus, M., Di Gregorio, M., & Carmenta, R. (2014). REDD+ policy networks: Exploring actors and power structures in an emerging policy domain. *Ecology and Society, 19*(4), 29.

Brockhaus, M., Korhonen-Kurki, K., Sehring, J., Di Gregorio, M., Assembe-Mvondo, S., Babon, A., & Kengoum, F. (2017). REDD+, transformational change and the promise of performance-based payments: A qualitative comparative analysis. *Climate Policy, 17*(6), 708–730.

Centola, D. (2018). *How behavior spreads. The science of complex contagion*. Princeton University Press.

Centola, D., & Macy, M. (2007). Complex contagions and the weakness of long ties. *American Journal of Sociology, 113*(3), 702–734.

Cronin, T., Santoso, L., Di Gregorio, M., Brockhaus, M., Mardiah, S., & Muharrom, E. (2016). Moving consensus and managing expectations: Media and REDD+ in Indonesia. *Climatic Change, 137*(1–2), 57–70.

Dunlop, C. A., & Radaelli, C. M. (2018). Does policy learning meet the standards of an analytical framework of the policy process? *Policy Studies Journal, 46*(S1), 48–68.

Fischer, M., & Sciarini, P. (2015). Unpacking reputational power: Intended and unintended determinants of the assessment of actors' power. *Social Networks*, *42*, 60–71.

Fischer, M., Ingold, K., & Ivanova, S. (2017). Information exchange under uncertainty: The case of unconventional gas development in the United Kingdom. *Land Use Policy, 67*, 200–211.

Gallemore, C., Di Gregorio, M., Moeliono, M., Brockhaus, M., & Prasti, H. R. D. (2015). Transaction costs, power, and multi-level forest governance in Indonesia. *Ecological Economics, 114*, 168–179.

Gebara, M. F., May, P. H., Carmenta, R., Calixto, B., Brockhaus, M., & Di Gregorio, M. (2017). Framing REDD+ in the Brazilian national media: How discourses evolved amid global negotiation uncertainties. *Climatic Change, 141*(2), 213–226.

Gerlak, A. K., Heikkila, T., Smolinski, S. L., Huitema, D., & Armitage, D. (2018). Learning our way out of environmental policy problems: A review of the scholarship. *Policy Sciences, 51*(3), 335–371.

Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology, 78*(6), 1360–1380.

Gouldner, A. W. (1960). The norm of reciprocity: A preliminary statement. *American Sociological Review, 25*(2), 161–178.

Gronow, A., & Ylä-Anttila, T. (2019). Cooptation of ENGOs or treadmill of production? Advocacy coalitions and climate change policy in Finland. *Policy Studies Journal, 47*(4), 860–881.

Gronow, A., Wagner, P., & Ylä-Anttila, T. (2020). Explaining collaboration in consensual and conflictual governance networks. *Public Administration, 98*(3), 730–745.

Guilbeault, D., Becker, J., & Centola, D. (2018). Complex contagions: A decade in review. In S. Lehmann & A. Yong-Yeol (Eds.), *Complex spreading phenomena in social systems Influence and contagion in real-world social networks.* (pp. 3–25). Springer.

Heikkila, T., & Gerlak, A. K. (2013). Building a conceptual approach to collective learning: Lessons for public policy scholars. *Policy Studies Journal, 41*(3), 484–512.

Heikkila, T., Pierce, J. J., Gallaher, S., Kagan, J., Crow, D. A., & Weible, C. M. (2014). Understanding a period of policy change: The case of hydraulic fracturing disclosure policy in Colorado. *Review of Policy Research, 31*(2), 65–87.

Henry, A. D., Dietz, T., & Sweeney, R. L. (2020). Coevolution of networks and beliefs in US environmental risk policy. *Policy Studies Journal*. https://doi.org/10.1111/psj.12407.

Hunter, F. (1953). *Community power structure*. University of North Carolina Press.

Ingold, K., Nohrstedt, D., Henry, A. D., Jenkins-Smith, H. C., & Weible, C. M. (2019). Revisiting policy-oriented learning. Paper presented at the *ECPR General Conference*, Wroclaw, Poland. https://ecpr.eu/Filestore/paperproposal/bc7244cd-56d7-4dfa-ab7b-20c9ac99a619.pdf.

Ingold, K., Fischer, M., & Cairney, P. (2017). Drivers for policy agreement in nascent subsystems: An application of the advocacy coalition framework to fracking policy in Switzerland and the UK. *Policy Studies Journal*. https://doi.org/10.1111/psj.12173.

Korhonen-Kurki, K., Brockhaus, M., Sehring, J., Di Gregorio, M., Assembe-Mvondo, S., Babon, A., Bekele, M., Benn, V., Gebara, M. F., Kambire, H. W., Kengoum, F., Maharani, C., Menton, M., Moeliono, M., Ochieng, R., Paudel, N. S., Pham, T. T., Dkamela, G. P., & Sitoe, A. (2019). What drives policy change for REDD+? A qualitative comparative analysis of the interplay between institutional and policy arena factors. *Climate Policy, 19*(3), 315–328.

Korhonen-Kurki, K., Sehring, J., Brockhaus, M., & Di Gregorio, M. (2014). Enabling factors for establishing REDD+ in a context of weak governance. *Climate Policy, 14*(2), 167–186.

Leach, W. D., Weible, C. M., Vince, S. R., Siddiki, S. N., & Calanni, J. C. (2013). Fostering learning through collaboration: Knowledge acquisition and belief change in marine aquaculture partnerships. *Journal of Public Administration Research and Theory, 24*(3), 591–622.

Leifeld, P. (2013). Reconceptualizing major policy change in the advocacy coalition framework: A discourse network analysis of German pension politics. *Policy Studies Journal, 41*(1), 169–198.

Levy, J. S. (2008). Case studies: Types, designs, and logics of inference. *Conflict Management and Peace Science, 25*(1), 1–18.

Lewis, K., Gonzalez, M., & Kaufman, J. (2012). Social selection and peer influence in an online social network. *Proceedings of the National Academy of Sciences, 109*(1), 68–72.

McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology*, *27*(1), 415–444.

Moeliono, M., Gallemore, C., Santoso, L., Brockhaus, M., & Di Gregorio, M. (2014). Information networks and power: confronting the "wicked problem" of REDD+ in Indonesia. *Ecology and Society, 19*(2), 9.

Moyson, S. (2017). Cognition and policy change: The consistency of policy learning in the advocacy coalition framework. *Policy and Society, 36*(2), 320–344.

Nepstad, D., McGrath, D., Stickler, C., Alencar, A., Azevedo, A., Swette, B., Bezerra, T., DiGiano, M., Shimada, J., Seroa da Motta, R., Armijo, E., Castello, L., Brando, P., Hansen, M. C., McGrath-Horn, M., Carvalho, O., & Hess, L. (2014). Slowing Amazon deforestation through public policy and interventions in beef and soy supply chains. *Science, 344*, 1118–1123.

Newig, J., Günther, D., & Pahl-Wostl, C. (2010). Synapses in the network: Learning in governance networks in the context of environmental management. *Ecology and Society, 15*(4), 1–16.

Pham, T. T., Di Gregorio, M., Carmenta, R., Brockhaus, M., & Le, D. N. (2014). The REDD+ policy arena in Vietnam: Participation of policy actors. *Ecology and Society, 19*(2), 22.

Riche, C., Aubin, D., & Moyson, S. (2020). Too much of a good thing? A systematic review about the conditions of learning in governance networks. *European Policy Analysis*. https://doi.org/10.1002/epa2.1080.

Sabatier, P. A. (1998). The advocacy coalition framework: Revisions and relevance for Europe. *Journal of European Public Policy, 5*(1), 98–130.

Sabatier, P., & Jenkins-Smith, H. (Eds.). (1993). *Policy change and learning: An advocacy coalition approach.* Westview Press.

Sprague, D. A., & House, T. (2017). Evidence for complex contagion models of social contagion from observational data. *PLoS ONE, 12*(7), e0180802.

Stern, N. (2006). *The Economics of Climate Change*. Cambridge University Press.

Thuy, P. T., Ha, H. M., & Campbell, B. M. (2008). Pro-poor payments for environmental services: Challenges for the government and administrative agencies in Vietnam. *Public Administration and Development, 28*(5), 363–373.

Wagner, P. M., & Ylä-Anttila, T. (2018). Can policy forums overcome echo chamber effects by enabling policy learning? Evidence from the Irish climate change policy network. *Journal of Public Policy, 40*, 212–213.

Weible, C. M., Heikkila, T., Ingold, K., & Fischer, M. (2016). Introduction. In C. M. Weible, T. Heikkila, K. Ingold, & M. Fischer (Eds.), *Policy debates on hydraulic fracturing. Comparing coalition politics in North America and Europe.* (pp. 1–27). Palgrave Macmillan.

Weible, C. M., & Ingold, K. (2018). Why advocacy coalitions matter and practical insights about them. *Policy & Politics, 46*(2), 325–343.

Weible, C. M., & Sabatier, P. A. (2009). Coalitions, science, and belief change: Comparing adversarial and collaborative policy subsystems. *Policy Studies Journal, 37*(2), 195–212.

Williams, A. P. (2001). A belief-focused process model of organizational learning. *Journal of Management Studies, 38*(1), 67–85.

Zito, A. R., & Schout, A. (2009). Learning theory reconsidered: EU integration theories and learning. *Journal of European Public Policy, 16*(8), 1103–1123.