Contributions by Interest Groups to Lobbying Coalitions

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Abstract. The composition of lobbying coalitions may affect how much effort interest groups contribute to them. First, partisan diversity within a coalition may enhance contributions from interest groups if bipartisanship is seen as a positive signal of the coalition’s likely success, or it may undercut contributions if it makes it harder for coalition members to work together. Second, network embeddedness may enhance contributions from coalition members if relationships make it easier to work together, or it may impede contributions if relationships resurrect conflicts or reduce the willingness of members to seek new information. Using a Two-Mode Exponential Random Graph Model (ERGM) with structural zeros, the study draws upon interviews with congressional staff members, interest group representatives, and coalition representatives working on health policy in the United States. The results demonstrate robust, positive effects of partisan diversity on contributions by interest groups to lobbying coalitions, but show only mixed effects of embeddedness.

Keywords. Partisanship, diversity, social networks, embeddedness, interest groups, lobbying, coalitions, collective action, health policy, United States, two-mode networks, exponential random graph models (ERGMs), structural zeros.
A lobbying coalition exists any time that two or more autonomous interest groups agree to work together in advocating for a common position on a policy issue (Wilson 1995). Participating in coalitions is a flexible way for interest groups to respond to the wide range of advocacy challenges that they encounter when engaging with policymakers. Coalitions may be small or large, temporary or permanent, informal or highly structured, and narrow or broad in their concerns (Tarrow 2005).

When interest groups choose to work together and how they form coalitions has been the subject of numerous studies (see Baumgartner et al. 2009; Heaney 2004; Hojnacki 1997; Hula 1999; Mahoney 2008; Mahoney and Baumgartner 2015; Scott 2015). Marie Hojnacki (1997) demonstrates that interest groups make decisions about whether to join coalitions by weighing the benefits – such as sharing resources and establishing a united front – against the costs – such as the loss of autonomy during collective advocacy and the public-relations risks of joining a debate on a controversial issue (see also Mahoney 2008). Coalition formation is promoted by preexisting networks between interest groups that provide the informational context for trust to develop between advocates, the visibility of central network positions, and endogenous processes of network formation (Box-Steffensmeier and Christenson 2014; Heaney 2004; Park 2008; Scott 2015; Simpson 2015). The success of interest groups in attaining policy influence depends in part on their ability to position themselves strategically within these networks (Box-Steffensmeier, Christianson, and Hitt 2013; Heaney 2006, 2014; Heaney and Lorenz 2013).

Despite the ubiquity of lobbying coalitions, their internal organization and politics has received only limited attention from scholars. Marie Hojnacki (1998) and Kevin Hula (1999) document considerable variation in contributions by interest groups to coalitions; some interest groups act as leaders, while others assume more specialized or peripheral roles. Hojnacki and Hula establish that which role a group plays depends on factors such as the degree to which the interest group cares about an issue and how its reputation among other groups would be affected by its
participation. These studies are significant because they problematize the extent to which the members of a lobbying coalition act in concert with one another. Just as there are collective action problems among groups in initially forming coalitions, so too are there collective action problems within coalitions as they engage with the policy process. Making sense of coalition politics not only requires modeling why an interest group joins a coalition, but also why some interest groups actively contribute to and lead the coalition, while others assume a more passive position. Therefore, we analyze recognized leadership contributions by interest groups to coalitions as a dependent variable.

Understanding the conditions under which coalitions are able to work together is a vital piece of the puzzle of which interests are represented most effectively in the policy process. However, prior studies provide an incomplete picture of coalitional collaboration. Specifically, their evidence and analysis focuses only on interest groups; they explain why interest groups vary their effort in coalitions, in general, without explaining why that effort might be contingent on the nature of the coalition in question. That is, they neglect to examine the coalition level of analysis and fail to explain why some coalitions may attract different amounts of participation than others. A more complete analysis ought to examine the interaction between individual interest groups and specific coalitions; it would model how a particular interest group distributes effort (equally or unequally) across the coalitions of which it is a member.

We argue that a key reason why interest groups vary in the degree to which they contribute effort to coalitions of which they are members is because distinct coalitions are composed of different sets of other interest groups. That is, contributions depend in part on who is on the coalition’s team. For example, an interest group may devote more effort to Coalition A than to Coalition B because it is more compatible with the other groups in A than in B. Thus, understanding interest group contributions to coalitions requires theorizing about what makes interest groups compatible (or not) with one another in a coalition setting.
This study focuses on two aspects of the composition of coalitions that we suspect may play a critical role in the ability of their members to collaborate with one another. *Diversity* is the first aspect of coalition composition that we examine. Does the coalition consist of members that tend to be homogeneous or heterogeneous with one another? There are numerous ways in which coalitions may be diverse, such as with respect to their members’ organizational types, geographic origins, resources, or preferred tactics. We concentrate on partisan diversity because partisanship is one of the principal identifying features of political actors in the contemporary United States (Green, Palmquist, and Schickler 2002; Heaney and Rojas 2015; Sinclair 2006). We ask whether a coalition elicits greater contributions from its members when it is more homogeneous – that is, its members tend to be similar to one another in their partisan identification – or more diverse – that is, its members tend to be closely identified with different parties.

*Network embeddedness* is the second aspect of coalition composition that we consider. Embeddedness is the extent to which members of a network are connected to one another by multiple, overlapping, ongoing relationships (Granovetter 1985). Does the coalition consist of interest groups that are tied to one another through a variety of relationships? For example, have interest groups in the coalition worked together in prior coalitions, do they share close contacts with some of the same policymakers, or do they rely on the some of the same sources of funding? Or are the groups in the coalition relative strangers to one another? We ask whether a coalition elicits greater contributions from its members when they are more closely connected with one another.

This article begins by theorizing how coalition composition affects contributions by member organizations. It develops hypotheses regarding the effects of partisan diversity and network embeddedness, as well as how these factors may interact with one another. Next, it describes an empirical research project to test these hypotheses based on interviews with representatives of interest groups and coalitions, as well as congressional staff members. To examine these data, it
builds Two-Mode Exponential Random Graph Models (ERGMs) in order to conduct statistical analysis. Finally, it discusses the results, their limitations, and implications.

This article contributes to knowledge about interest groups, political coalitions, diversity, and social networks. For interest group politics, it provides a basis for understanding the mechanisms of collective action among interest groups after they have already committed to a cause, thus expanding upon the extant literature that concentrates on the initial commitment decision by groups. For the study of political coalitions, it offers a rare, systematic analysis of behavior inside of coalitions, accounting for how the composition of their members affects the coalition as a whole. For the study of diversity, it adds a new kind of context to understand the effects of diversity on cooperation. For the study of social networks, it provides a political example of analysis of two-mode data with extensive structural zeros. We are unaware of any previous empirical studies that examine this particular network data structure.

1. **Coalition Composition and Member Contributions**

The decision by an interest group to join a lobbying coalition is a decision to lend its name to the coalition’s cause. By doing so, the interest group conveys to its allies in government, other advocacy groups, and the public that it is willing to put its reputation behind the coalition. Doing so may assist in achieving the coalition’s goals, especially if the interest group is prominent or represents a niche constituency that the coalition would like to claim to represent, such as a vital industry, ethnic minority, or ideological perspective.

While there is certainly a place for some – perhaps even most – of the members of a coalition to act in name only, if a coalition is to accomplish its goals, then some subset of its members must contribute effort to the coalition’s work. This work may involve attending coalition meetings, lobbying policymakers, drafting letters, holding press conferences, or deploying other tactics that the coalition may decide upon. The extent to which an interest group contributes
substantially to the collective action of the coalition likely depends on a variety of factors. It may depend on the extent to which the interest group is committed to the issues addressed by the coalition, whether it has staff and resources to contribute to the effort, as well as its expectations about the prospects for success by the coalition. These calculations may also depend on an interest group’s commitments to other coalitions in its coalition portfolio (Heaney and Lorenz 2013); a group has to decide how much effort to allocate to each of the coalitions which it has joined.

The willingness of an interest group to contribute effort to any particular coalition of which it is a member likely depends, in part, on the composition of the coalition. Do the members of the coalition make a good team? Interdisciplinary research on teams has long examined how a team’s composition affects its performance (Bell 2007; Carter et al. 2015). Two key questions in this area are, first, what is the best mix of types for the members of a team (Mannix and Neal 2005)? In particular, is it better to have a team made up of similar or diverse members? Second, how do the relationships among members of a team affect the way the team operates (Leenders, Contractor, and DeChurch 2016)? Does it make a difference if members of a coalition are closely embedded with one another or if they are relative strangers to one another? In the following three sections, we discuss these questions in the context of lobbying coalitions and derive testable hypotheses that relate to them.

Partisan Diversity. Scott Page (2007) explains that there are both potential advantages and disadvantages of diversity in teams. On the positive side, more diverse teams have the potential to bring more varied perspectives, interpretations, heuristics, and predictive models to bear on a problem. If these differences are relevant to the problem at hand, then diversity may increase the likelihood that the team will be successful. On the negative side, diversity may make it more difficult for the members of a team to get along with one another, especially if diversity is coupled with animus or lack of understanding. If the team’s task is primarily conjunctive – that is, everyone’s
contribution is critical – then diversity may disrupt the team’s work more than it helps it.

The ability of members to work together and solve problems is likely as important in lobbying as it is in many other fields. The composition of a coalition may matter not only because of the work that the coalition actually does, but also because external audiences observe the formation of the coalition and attach political significance to who its members are. As Ken Kollman (1998) argues, policymakers look to political mobilizations for signals of the likely consequences of taking different positions on an issue. From a signaling perspective, the existence of a diverse coalition may be particularly powerful because it indicates that actors who usually have reasons to disagree with one another have found a way to resolve their differences, thus suggesting that their position may be worthy of close examination (Phinney 2010). On the other hand, diversity in a coalition may provide a negative signal if the coalition brings together groups that some power holders would prefer not to see working together.

If the interest groups in a coalition are closely connected with different parties, then they might be more likely to bring different perspectives and approaches to the coalition than if they are closely connected with the same party. Moreover, if a coalition has united interest groups across partisan boundaries, this unity may signal that it has overcome differences that may contribute to legislative polarization and stalemate. Prior research suggests that interest groups that form networks across partisan boundaries have greater reputations for policy influence than interest groups that do not cross these boundaries (Heaney 2006). Thus, coalitions with greater partisan diversity may be a better investment for interest groups’ time and effort than coalitions that are more homogeneous on this dimension. Based on these arguments, we state

Hypothesis 1a: Members of a lobbying coalition are more likely to contribute effort to the coalition when interest groups in the coalition have greater partisan diversity than when the interest groups in the coalition have greater partisan homogeneity.
Alternatively, partisan diversity may create problems for a coalition. Interest groups that are closely connected to different parties may experience ideological disagreements, clashes of loyalty, and other conflicts that make it less likely that the members will actively work together. Moreover, coalitions that cross partisan boundaries may be a negative signal to party leaders that prioritize loyalty to the party (Pearson 2015). Hence, interest groups that find themselves in a coalition with much partisan diversity may believe that too much active participation in the coalition risks bringing on the wrath of party leaders in government. Based on these arguments, we state Hypothesis 1b: Members of a lobbying coalition are less likely to contribute effort to the coalition when the interest groups in the coalition have greater partisan diversity than when the interest groups in the coalition have greater partisan homogeneity.

Network Embeddedness. If members of a team are to work well together, it is important that they trust one another (Lin 2001). An important question for understanding teams, then, is what are the conditions under which their members are likely to trust one another? A significant strand of institutional theory holds that the structure of institutions is critical to establishing the conditions for trust (Alchian and Demsetz 1972; Miller 1992; Williamson 1975). For example, institutions may be able to enhance trust by adequately monitoring the contributions of members of team. In contrast, Mark Granovetter (1985, p. 4, emphasis in original) argues that the institutional perspective is incomplete since “[t]he widespread preference for transacting with individuals of known reputation implies that few are actually content to rely on either generalized morality or institutional arrangements to guard against trouble.” He argues that trust is fostered by being closely connected with other actors in recurrent relationships that are embedded in intricate social structures.

Prior research demonstrates that embeddedness affects the willingness of interest groups to share information with one another and join together in coalitions (Carpenter, Esterling, and Lazer 2004; Heaney 2004; Scott 2015). There are reasons to expect that these effects are likely to matter to
groups’ efforts inside coalitions. Since working in a coalition may require interest groups to share
sensitive information and strategies with one another, they may be more inclined to work closely
with those that are integrated into the same networks and relationships than those with which they
are more distantly connected. Moreover, working with closely embedded interest groups may be
smoother and have lower transaction costs than working with interest groups that are less closely
embedded. Finally, embeddedness may create social obligations and expectations for future
interactions – a “shadow of the future” (Axelrod 1984) – that may motivate interest groups to
contribute to a coalition. Thus, interest groups may put more effort into coalitions the more closely
that they are embedded within them. Based on these arguments, we state

Hypothesis 2a: Members of a lobbying coalition are more likely to contribute to a coalition when they are more
closely embedded with other interest groups in the coalition than when they are more socially distant from these
groups.

However, it is also possible for actors to become “overembedded” such that they reach a
point where excessively closely connected networks serve to undermine the effectiveness of a team
in working together (Burt 1992; Uzzi 1996). For example, reliance upon embedded relationships
may discourage actors from building new relationships or seeking out other sources of information.
In that case, social network ties may be unnecessary or harmful to the coalition’s collaboration.
Coalitional institutions may be sufficient to generate the trust needed for interest groups to work
together effectively, thus reducing or eliminating the importance of networks. Further, members of
coalitions may become so closely connected that their social relationships interfere with the
coalition’s operation. Based on these arguments, we state

Hypothesis 2b: Members of a lobbying coalition are equally or less likely to contribute to a coalition when they are
more closely embedded with other interest groups in coalition than when they are more socially distant from
these members.
Interactions between Diversity and Embeddedness. The preceding analysis assumes that the partisan diversity of interest groups and their networks with one another are unrelated aspects of the composition of a coalition. Yet, in practice, these two aspects may be closely related. The tendency of actors of the same type to be more likely than actors of different types to form ties in networks is the well-established principle of homophily (McPherson and Smith-Lovin 1987). Thus, it is reasonable to expect that coalitions with homogeneous types of members are likely to be relatively more closely embedded in networks than are coalitions with diverse types of members. This principle is especially likely to hold in our case because co-partisanship is a notably strong predictor of network tie formation in an era of partisan polarization (Heaney et al. 2012). That is, two Democratic-leaning or Republican-leaning groups are likely to be tied with one another, but one Democratic-leaning and one Republican-leaning group are relatively less likely to form a relationship.

An important question for coalition politics is whether the participation of members in the coalition is affected by interactions between the partisan diversity of members in the coalition and the degree of their network embeddedness with one another. It is conceivable that these interactions have either positive or negative effects on member contributions. Considering first the positive case, it is possible that partisan diversity and network embeddedness are complementary to one another. Such complementarity could be present if embeddedness helped to offset some of the negative aspects of working with interest groups closely tied to members of the opposite party. In such a situation, the hesitancy of members to contribute to a bipartisan coalition may be ameliorated when the members of the coalition are closely embedded with one another; they trust each other despite their partisan differences. Based on these arguments, we state Hypothesis 3a: Partisan diversity and network embeddedness interact positively in promoting interest group contributions to a coalition.

Considering second the negative case, it is possible that partisan diversity and network
embeddedness undercut one another. Partisan tensions could be exacerbated when organizations that have fundamental disagreements with one another also find themselves closely connected through common networks. Thus, partisan diversity and network embeddedness may trade off with one another. In such a situation, coalition managers may be well advised to choose between the strategy of assembling a coalition that is diverse and a coalition that is closely interconnected. Otherwise, probable inter-member conflicts may dampen interest group contributions to the coalition. Based on these arguments, we state

Hypothesis 3b: Partisan diversity and network embeddedness interact negatively in promoting interest group contributions to a coalition.

2. Research Design

A study that examines the effects of membership composition on contributions to coalitions must have several features. First, it must observe the same organizations acting within different coalitions so that the willingness of an organization to contribute to a particular coalition can be distinguished from its willingness to contribute to coalitions in general. Second, it must observe multiple organizations acting within the same coalition so that an account can be provided for why some organizations contribute to the coalition and others do not. Third, it must observe a variety of coalitions so that the effects of the coalition itself and its political-organizational features can be identified. Fourth, it must observe organizations within a coherent domain of politics such that organizations are networked with one another. Fifth, it must observe organizations within a broad enough area of politics such that there is sufficient opportunity for organizations in the study to vary with respect to their contributions, partisan diversity, network embeddedness, and other salient features. A sample constructed within these parameters would set the stage for a test of the hypotheses outlined in this article.

In order to satisfy these criteria, a sample of interest groups and coalitions was selected from
a single, prominent policy domain: health policy. Since it is among the largest and most diverse policy areas in the United States, health involves a wide range of issues, such as government-financed health care, pharmaceutical regulation, the education of medical professionals, health insurance, public health, reproductive rights, and medical research. Because of their broad impact on society, health policy debates draw involvement from interest groups outside the field of health—such as business associations, labor unions, veterans’ service organizations, and citizens’ advocacy groups—as well as groups focused on health—such as doctors, nurses, pharmacists, para-health professionals, hospitals, pharmaceutical companies, medical device manufacturers, and insurance companies. Health policy is broad enough that it contains many different types of politics; for example, the politics of providing veterans’ health benefits are not very similar to the politics of providing reproductive health services. At the same time, the issue area is narrow enough that many of the interest groups and coalitions in this field are interconnected with one another.

We derived a sample of the most prominent health policy interest groups active at the national level in the United States in 2003 by using multiple criteria, as is required by the boundary specification principles of Laumann, Marsden, and Prensky (1989). First, the federal lobbying reports of interest groups were examined if they indicated that the interest group lobbied on health care, Medicare and Medicaid, or medical research issues from 1997 to 2002 (U.S. Senate, Office of Public Records 2003). Interest groups from this list were ranked based on their reported federal lobbying expenditures. Second, interest groups were ranked based on the number of times that they testified at health policy related hearings on Capitol Hill from 1997 to 2002 (LexisNexis 2003). Any interest group that ranked among the top 50 groups on either of the first two lists, or among the top 100 groups on both lists, was included in the study. Third, interest groups with a long history of involvement in health policy debates were included (based on data from Laumann and Knoke 1987). Fourth, a preliminary list of interest groups, which was compiled based on the first three sources,
was circulated to a panel of experts from academia and the policy world to solicit additional recommendations. Any interest group recommended by at least two experts was included in the study. This procedure led to the identification of 171 interest groups as the “most active” groups in the health policy domain.¹

After identifying the sample of interest groups, data were collected by executing three waves of interviews. The first wave of interviews was conducted with 95 congressional staff members working on health policy (49 Republicans and 46 Democrats, a proportionate split based on control of Congress at the time). These interviews yielded information on the reputations of interest groups for partisanship. The second wave of interviews was conducted by inviting representatives of each of the 171 interest groups to participate in a personal interview. Interviews were ultimately conducted with representatives of 168 groups in the sample, which yielded data on coalition memberships. These data were supplemented with data on lobbying resources, organizational structure, and organizational age. Coalition memberships of the 3 organizations that did not participate in the study were derived from information provided by other interview respondents.

The third wave of interviews was derived from information obtained in the second wave, which allowed us to establish which interest groups were members of which coalitions. We asked our second wave of respondents to list their coalition memberships for us. We then obtained membership lists (official when possible, unofficial when necessary) for each coalition named by the respondents in order to ensure a more reliable record of coalition memberships than is possible based on respondent recall alone. We used the rule that any coalition that counted among its members at least 5 of the 171 most prominent interest groups was selected for the third wave, yielding a total of 80 coalitions for further analysis.² Representatives of each of the 80 coalitions

¹ The complete list of all interest groups included in the study is provided in Online Appendix A 1.

² The complete list of all coalitions included in the study is provided in Online Appendix A 2.
were contacted in 2004 and invited to participate in an anonymous, personal interview. Of these, representatives of 74 coalitions agreed to participate in the study.

During the third wave of interviews, each respondent was shown a list of all the members of her or his coalition. We determined the degree of contribution by interest groups to the coalition based on whether they were identified as one of the leaders of the coalition. Respondents were asked: “Please look at the list of members of the coalition. Which organizations would you identify as the leaders of the coalition? Leadership need not necessarily be indicated by a formal position, but may also be suggested by the informal contribution that the organization makes to the work of the coalition.” Responses to this question constitute the dependent variable for the study.

While some scholars describe a “leader” as a single, elected person who directs a hierarchical organization, the use of the concept of leadership in the context of coalitions – which are voluntary groupings of autonomous organizations – is more akin to what is known as “distributed” or “endogenous” leadership (Ahlquist and Levi 2011, pp. 13-14; Spillane 2006). From this perspective, leadership is indicated more by the tasks performed by the actor than by its formal position. Leaders are those whose behavior is a guide to others and enables them to achieve their goals. In this sense, elected leaders may fail to exert leadership, while unelected actors may be critical to leading a group. Direct participants in coalition politics generally use concepts of distributed leadership to describe how coalitions work (see Leavitt and McKeown 2013, p. 67). Along these lines, the coordinator of a coalition advocating for children’s interests explained in an anonymous interview in 2015 that “a leader helps to drive the coalition’s discussion and decision making. They are very active in the coalition” (Anonymous Interview, September 2015) This perspective recognizes that a coalition may have more than one interest group as its leader, depending on how much of a contribution each organization makes to it. As coalitions and their internal decision modes are diverse, we deliberately chose to adopt such an open question that acknowledges
different kinds of leadership provision, yet allowing a comparison across coalitions due to the standardized nature of the interview.

3. **Network Analysis of Two-Mode Data**

The data collected for this study allow for the analysis of recognized leadership contributions (our measure of effort) by 171 interest groups in 74 lobbying coalitions. On average, each interest group in the sample joined 6.25 of the coalitions in the study, ranging from a minimum of 0 to a maximum of 22. On average, each coalition had 14.46 interest group members from the sample, ranging from a minimum of 5 (by design) to a maximum of 39.

Recognition of leadership contributions were less widely distributed than was membership. Each interest group was recognized as a leader in an average of 1.53 coalitions, ranging from a minimum of 0 to a maximum of 11. Each coalition had an average of 3.66 recognized leaders, ranging from a minimum of 0 to a maximum of 13. Based on these data, it is fair to conclude that interest groups vary in the degree to which they are recognized for supplying leadership contributions to the coalitions of which they are members, while coalitions differ in the leadership contributions that they recognize receiving.

We conceptualize interest groups and coalitions as two-mode networks, or bipartite graphs, with interest groups and coalitions as separate classes of nodes. In a bipartite graph, edges are allowed between the two node classes but not within either class of nodes. We model the presence or absence of recognized leadership by interest groups in coalitions (i.e., the “ties” in the study) as the dependent variable. However, as these leadership dyads are potentially dependent on each other, we employ inferential network analysis to model these observations as a joint multivariate system rather than a collection of independent observations. A formal description of this data structure is given in the Online Appendix A3.

An illustration of the structure of these data is provided in Figure 1a. Interest groups are
represented as the first mode and constitute the rows of the network matrix. Coalitions are represented as the second mode and constitute the columns of the network matrix. A value of 1 in a cell (i.e., a “tie”) indicates that an interest group is a member of the coalition and is recognized as making a leadership contribution to the coalition. A value of 0 in a cell indicates than an interest group is a member of the coalition, but is not recognized as making a leadership contribution to the coalition. A value of X in a cell indicates that an interest group is neither a member of the coalition nor is recognized as contributing leadership. The Xs represent the “structural zeros” of the network: they are instances where a positive value of 1 is not possible within the framework under which the data were collected. The statistical analysis of such a network would reveal why an interest group is recognized as contributing leadership to a coalition, conditional on its being a coalition member.

INSERT FIGURE 1 HERE

The structure of the network is also illustrated graphically in Figure 1b, which considers a random sample of four coalitions drawn from the data. These coalitions are the Consortium for Citizens with Disabilities (a.k.a., CCD), the Coalition to Fight Sexually Transmitted Diseases (a.k.a., the Coalition to Fight STDs), the Ad Hoc Group for Medical Research Funding (a.k.a., the Ad Hoc Group), and the Health Benefits Coalition for Affordable Choice and Quality (a.k.a., the Health Benefits Coalition). In this graph, interest groups are represented by white circles, coalitions by gray squares; membership ties are represented by thin lines, and leadership ties by thick lines. Structural zeros are indicated by the absence of lines between circles and squares.

Three of the four coalitions in Figure 1b share interest groups with one another. It is apparent from the graph that CCD and the Ad Hoc Group share three members, CCD and the Coalition to Fight STDs share one member, and the Ad Hoc Group and the Coalition to Fight STDs share five members. There is exactly one interest group that is a member of all three of these
coalitions. On the other hand, the Health Benefits Coalition does not share any members with the other three coalitions. There are notable variations among the coalitions in the likelihood that interest groups are recognized as making leadership contributions. In the Health Benefits Coalition, 8 of the 11 members (73 percent) are recognized as making leadership contributions. The rate of leadership recognition is 42 percent for CCD, 32 percent for the Ad Hoc Group, and 5 percent in the Coalition to Fight STDs.

Use of the exponential random graph model (ERGM) enables us to account for specified network dependencies in the data (Frank and Strauss 1986; Robins and Morris 2007; Cranmer and Desmarais 2011). In an ERGM framework, we can model a network by describing how the network is composed of endogenous local structures and how its structure is additionally co-determined by exogenous covariates, such as nodal attributes, that increase or decrease the tie probability of a dyad. This model captures both the dependencies between observations as well as covariate effects. Two interpretations of ERGMs are: (1) a global interpretation where the probability of an observed network over the networks one could have observed is considered; and, (2) a local interpretation where the same probability governs whether any particular edge in the network is realized. In an ERGM, the probability of an observed network topology over the networks one could have observed is modeled as

$$P(N, \theta) = \frac{\exp \{ \theta' h(N) \}}{\sum_{N^* \in \mathcal{N}} \exp \{ \theta' h(N^*) \}}$$

where $N$ is a matrix representing the observed network, $\theta$ are the coefficients that need to be computed, $h(N)$ is a vector of statistics to be included in the model (including the aforementioned endogenous dependencies and exogenous covariates), and $N^*$ refers to a particular permutation of the topology of the network from the set of all possible permutations of the topology of the network, denoted as $\mathcal{N}$ (Cranmer and Desmarais 2011). The denominator acts as a normalizing
constant to scale the probability between 0 and 1. ERGMs are typically estimated by Markov Chain Monte Carlo Maximum Likelihood Estimation (MCMC MLE) because the denominator contains a sample space that is too large to be evaluated using exhaustive optimization algorithms.

Two non-standard constraints to this default ERGM definition are necessary in the context of the present analysis. First, we analyze a two-mode network, which does not allow edges within node classes. Therefore, all group-group dyads and all coalition-coalition dyads are constrained to be zero in any $N^* \in \mathcal{N}$ (so-called structural zeros). This constraint means that we must adjust the size of the sample space to contain only network matrices in which no positive entries are present in these within-mode dyads. Second, $N^* \in \mathcal{N}$ must never contain any edges that are not contained in the membership graph. Hence, we must also add structural zeros where a group is not a member of a coalition to effectively prohibit leadership ties to be predicted where membership does not exist. These deviations from the standard probability density function in ERGMs are required for an appropriate scaling of the probability. Without these corrections, the probability of the observed graph would be underestimated relative to what could have been observed. At the estimation stage, the constraints are introduced by adding an edge covariate to $h(N)$ that contains a positive value in these entries (and 0 elsewhere) and by constraining the coefficient corresponding to this covariate in $\theta$ to be infinitely small.

Estimation of the statistical models is carried out using the ergm package (Hunter et al. 2008) from the statnet suite of packages (Handcock et al. 2008) for the statistical computing environment R. The goodness of model fit is assessed using the xergm package (Leifeld, Cranmer, and Desmarais 2016).

4. Empirical Models

We develop and test two ERGMs in the main text of the article. Model 1 represents a straightforward test of Hypotheses 1 through 3. The dependent variable is whether an interest
group is recognized for making a leadership contribution in a coalition, conditional on it being a member of the coalition. Hypotheses 1a and 1b are tested using *Partisan Diversity*, which is measured with the standard deviation of the partisan ratings of interest groups in a coalition; it is derived from interviews with congressional staff members. Hypotheses 2a and 2b are tested using *Network Embeddedness*, which is measured with the number of other coalitions that an interest group shares with the other interest groups in the coalition. It is derived from organizational members listed on the coalition’s web site, policy letters that it sent to members of Congress, and/or a list provided directly by the coalition’s representative during the interview. More specifically, *Network Embeddedness* is constructed by adding up the number of other coalitions through which an interest group is affiliated with another member of the current coalition, adding up these counts for all other coalition members, and standardizing the count by the maximal value this variable can assume for a given interest group-coalition dyad. This approach yields the extra-coalition embeddedness between an interest group and the members of the current coalition, standardized by coalition size.

Hypotheses 3a and 3b are examined using *Diversity X Embeddedness*, measured by multiplying *Partisan Diversity* by *Network Embeddedness*.

We include a series of control variables in Model 1, the first three of which account for the potential effects of partisanship on the coalition. *Interest Group Partisanship* is based on the partisan rating of the interest group by congressional staff, with Republican-leaning groups indicated by positive scores and Democratic-leaning groups indicated by negative scores. This variable checks for whether Democratic- or Republican-leaning groups are more likely to contribute to coalitions. *Coalition Partisanship* is the average of *Interest Group Partisanship* of all members of the coalition. It examines whether coalitions that lean Republican are more or less likely to recognize their members as leaders than are coalitions that lean Democratic. *Interest Group-Coalition Partisan Differential* is the absolute value of the difference between *Interest Group Partisanship* and *Coalition Partisanship*. It
evaluates whether an interest group is more or less likely to contribute to a coalition if it is close to or distant from the coalition’s average partisanship.

We include five control variables that represent key interest group characteristics. *Number of Coalition Memberships* gives an indication of how extended the interest group is in alliances across the policy domain. *Interest Group Age* (in years) accounts for the possibility that more established interest groups may differ from newer interest groups in their involvement in coalitions. *Citizens’ Advocacy Group* takes the value of 1 if the interest group advocates for a citizens’ issue, as opposed to advocating for a trade association, professional society, or other organizational interests. It allows for the possibility that citizens’ groups may participate in coalitions differently than other kinds of interest groups. *Lobbying Expenditures* is the dollar value of the interest group’s reported lobbying spending in 2003 under the Lobbying Disclosure Act. *Interest Group Crosses Issue Boundaries* takes the value of 1 if the interest group’s policy agenda comes from outside of the health area, 0 otherwise. For example, while the National Association of Manufacturers is certainly concerned about health policy, its primary policy focus is located outside of health, thus giving it a 1 on this variable.

We include six control variables that represent key coalition characteristics. *Coalition Size* is the number of interest groups in the sample that are members of the coalition. It allows for the possibility that larger coalitions will have fewer recognized leaders, possibly because they experience greater collective action problems as they get larger and/or because there are economies of scale in leading coalitions, reducing the need for more leaders as the coalition gets larger. *Coalition Age* (in years) enables us to evaluate if older coalitions differ in the recognition of their members as leaders than do younger coalitions. *Coalition Dues* takes the value of 1 if the coalition collects dues from its members, 0 otherwise, thus factoring in the coalition’s access to monetary resources. *Coalition Faces Legislative Threat* takes the value of 1 if the coalition is responding to a legislative threat, as opposed to being part of an effort to achieve policy gains. *Coalition Focuses on Authorizing Legislation* takes the
value of 1 if it focuses on the authoring legislation, as opposed to appropriations or disseminating policy information, which take the value of 0. Coalition Steering Committee takes the value of 1 if the coalition has a steering committee or other formalized leadership structure, 0 otherwise.

We include two variables to account for the endogenous structure of the networks that can capture dependencies between observations. Interest Group Mode Two-Stars accounts for clustered activity of groups that results from recognition of leadership contributions in multiple coalitions. Online Appendix A 3 contains a formal definition of the two-star model term. Edges accounts for the number of ties in the network. It is analogous to the constant in a generalized linear regression.

We develop Model 2 to recognize that some interest groups determine their leadership role prior to joining the coalition. In particular, the entrepreneurs that found a coalition exert their critical leadership contributions prior to the coalition coming into existence. We wish to separate these contributions from the contributions that emerge after the coalition comes into existence. Hence, Model 2 treats all cases in which an interest group was one of the founders of a coalition as a structural zero, thus adding 136 structural zeros (of which 102 were leadership ties out of a total of 271 leadership ties). This corresponds to an average of about 2 founding members per coalition. Thus, for Model 2, the dependent variable is that an interest group is recognized for making a leadership contribution in a coalition, conditional on it being a member of the coalition and that it was not a founder of the coalition. For this model, we include the same list of independent and endogenous variables as in Model 1.

In Online Appendix A 4, we present four additional models. Model 3 includes the same focal variables as Model 1, but omits the control variables to evaluate if their presence affects the conclusions about the main hypotheses. Model 4 includes the same variables as Model 1, but also includes measures of coalition diversity based on Interest Group Age, Citizens’ Advocacy Group, Lobbying Spending, and Interest Group Crosses Issue Boundary. Doing so evaluates whether other kinds of diversity,
besides Partisan Diversity, affect contributions to the coalition. Model 5 adds a measure of Coalition Communication Indegree, based on the interest group interviews, to see if it affects the conclusions of the model. Model 6 is similar to Model 1, but makes a few changes. We add a Coalition Mode Two-Stars term, which accounts for recognition of leadership contributions by multiple groups per coalition, to account for dependence in the coalition mode. To do so, we remove Number of Coalition Memberships and Coalition Size from the model, which are collinear with this term.

5. Results

Table 1 presents coefficients and standard errors for Models 1 and 2. In Model 1, we find a positive, statistically significant coefficient on Partisan Diversity, supporting H1a over H1b. This finding indicates that coalitions whose members have more partisan heterogeneity tend to have more recognized leadership contributions than do coalitions with more partisan homogeneity. Neither the coefficient for Network Embeddedness nor the coefficient for Diversity X Embeddedness are significant in this model, supporting H2b over H2a and supporting neither H3a nor H3b. These findings indicate that an interest group is not any more or less likely to be recognized for leadership contributions within a coalition if it shares many coalition memberships with its partners in the coalition than if it is in few coalitions with them.

The positive, significant coefficient for Partisan Diversity in Model 1 means that increased diversity in partisan leaning within a coalition corresponds with contributions from members. From an interest group perspective, a group is more likely to provide leadership contributions if the coalition in which it is a member has a high partisan diversity. In any group-coalition dyad, the effect size of 0.49 indicates that a one-point increase in diversity increases the odds of recognized leadership provision by about 66 percent. Diversity is the standard deviation of partisan leaning of a coalition’s members. This variable is measured on a scale from -16 to +17. The standard deviations vary across coalitions from a minimum of 1.34 to a maximum of 9.78 (mean=4.29). A one-point
increase in this standard deviation of partisan leaning leads to 66 percent higher odds of being tied.

The coefficient on Network Embeddedness is 29.37, though we have noted that this effect is insignificant. As network embeddedness is standardized by the maximal number of co-memberships all coalition members could potentially have, the variable has rather small values between 0.007 and 0.088, with a mean value of 0.037 and a standard deviation of 0.014. An increase of 0.01 on the network embeddedness variable, for example, is would thus be associated with a 37 percent increase in the odds of leadership provision, were this finding significant.

If it were significant, the interaction term between Partisan Diversity and Network Embeddedness would imply that an increase in network embeddedness and a simultaneous increase in diversity would lead to a decreasing probability of being tied. The reasoning would be that both effects crowd each other out as substitutes, once the main effects are controlled for. As expected, the effect size is between the size of the two main effects.

Among the control variables, Coalition Partisanship and Coalition Size are statistically significant. The positive coefficient on Coalition Partisanship implies that coalitions that lean more toward the Republican Party were recognized as receiving more leadership contributions than were Democratic-leaning coalitions, a finding that is almost certainly influenced by the fact that Republicans controlled the White House and Congress during this period. The negative coefficient on Coalition Size implies that as coalitions add new members, there is a marginal decrease in the likelihood of receiving new leadership contributions. This result is likely because of increased collective action problems in larger coalitions and/or because of economies of scale in coalition leadership. The coefficient on Interest Group Mode Two-Stars is positive and significant, which reveals positive network dependence, resulting from the fact that certain interest groups are more likely to be recognized as making leadership contributions to coalitions than are other interest groups. For example, the American Medical Association, AARP, and U.S. Chamber of Commerce are more widely recognized
for their leadership contributions to coalitions than are the American Osteopathic Association, the National Hemophilia Foundation, and the United Mine Workers of America.

INSERT TABLE 1 HERE

Model 2 differs from Model 1 in that it excludes interest groups that founded a coalition from the set of interest groups recognized as contributing leadership to the coalition, treating these cases instead as structural zeros. As in Model 1, we find a positive, significant coefficient on Partisan Diversity, reinforcing the support for H1a over H1b. However, unlike Model 1, we find a positive, significant coefficient on Network Embeddedness and a negative, significant coefficient on Diversity X Embeddedness. The positive coefficient on Network Embeddedness implies that when interest groups are in a coalition where they have other coalition collaborations with their partners, then they are more likely to be recognized as making a leadership contribution than when they are in a coalition with relative strangers. The negative coefficient on Diversity X Embeddedness reveals a trade-off between diversity and embeddedness. Interest groups are more likely to be recognized as making leadership contributions to coalitions with greater partisan diversity and in coalitions with more embeddedness but, when both factors are present, there is a marginal reduction in the number of groups recognized for their leadership contributions. Coalition Partisanship, Coalition Size, and Interest Group Mode Two-Stars have the same direction and significance as they do in Model 1. However, Model 2 also shows positive, significant effects of Interest Group Partisanship, Interest Group Age, and Citizen Advocacy Group.

Models 3 through 6, which are reported in Online Appendix A 4, examine the robustness of our analysis by considering variations in the specifications of Model 1. The results for Model 3 show that the positive, significant coefficient on Partisan Diversity is unchanged when the control variables are omitted. However, there is a positive, significant effect on Network Embeddedness and a negative, significant effect Diversity X Embeddedness, neither of which was significant in Model 1. In Model 4, we include alternative measures of diversity, none of which are statistically significant. The
fact that Partisan Diversity retains its positive, significant coefficient under these conditions shows that this particular type of diversity is important in our case.

In Model 5, we include a measure of Coalition Communication Indegree, based on communication networks among interest groups in a coalition, which is likely endogenously related to recognition of leadership contributions. We acknowledge that communication among the members of the coalition and being central in the communication network is likely important to recognizing leadership, but have withheld it from other models because of the difficulty of identifying how much of the effect is communication on leadership versus leadership on communication (i.e., bidirectional causality). It has a positive, significant coefficient in the model, though the result of including it in this model shows that it does not affect our conclusions about Partisan Diversity or Network Embeddedness. However, it does affect conclusions about Diversity X Embeddedness, which has a significant, negative coefficient in this model. Finally, Model 6 includes a Coalition Mode Two-Stars term, to control for dependence in the coalition mode, which we have not included in other models. The results show that this term is not statistically significant, reducing the concern about its omission from other models. Including this term, as well as dropping Number of Coalition Memberships and Coalition Size, does not affect our conclusions about Partisan Diversity, though it does affect our conclusions about Network Embeddedness and Diversity X Embeddedness, which are significantly positive and negative, respectively, in this case. This result suggests that network embeddedness is inversely related to coalition size: either being connected to coalition members outside of the current coalition or having a small coalition breeds trust among coalition members, thus encouraging leadership contributions. As Model 2 suggests, this is especially the case for secondary members (i.e., those who did not found the coalition).

We evaluate the relative goodness of fit of Model 1 by simulating 1,000 new networks from each of the models and comparing these simulations to the observed leadership network. First, we
compare several distributions of relevant network statistics: the number of non-edge-wise shared partners, the geodesic (i.e., shortest path) distance between members of a dyad, the distribution of degree centrality of nodes in the network, and the number of $k$-stars at varying levels of $k$.$^3$ If the simulated distributions (represented by boxplots in Figure 2) approximately match the observed network (represented by a black line in Figure 1), then the model captures the network properties of the observed leadership graph well and does not suffer from omitted variable bias with regard to endogenous dependencies. With the exception of the second-mode (coalition mode) $k$-star, Figure 2 shows that Model 1 fits the data very well in terms of its network properties. This fit could be improved by adding a term to the model for Coalition Mode Two-Star (which we do in Model 6), but doing so would come at the cost of removing Number of Coalition Memberships and Coalition Size from the model, which are collinear with the Coalition Mode Two-Star variables. The other models display similar degrees of endogenous fit with the data.

The Online Appendix contains more information about model fit and diagnostics, including goodness-of-fit graphs for Models 2-6 (Online Appendix A 5), precision-recall curves within-sample classification performance in terms of the fraction of ties successfully predicted by the model versus the type II error with such a prediction is made (Online Appendix A 6), the MCMC trace plots as an indicator of convergence (Appendix A 7), and the complete replication code (Appendix A 8).

In terms of the generalizability of our results, an important consideration is how typical health care coalitions are of coalitions in other areas of the public policy process. We believe that because the health policy field is both large (in terms of the number of active groups) and broad (in terms of the diversity of issues it addresses), that health coalitions – on average – are not deviant from coalitions in other policy domains. Indeed, a recent study by the lead author and another

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$^3$ A $k$-star is a network configuration of $k$ nodes that each has one connection to a central node.
colleague documents this comparability. In the summer of 2014, they interviewed lobbyists working for 124 randomly-selected interest groups from any area of public policy. They asked the respondents to list the coalitions that they had worked with the past year. They then followed up with a second round of interviews with leaders of 84 coalitions randomly selected from this set. They found that 34 of these coalitions (40 percent) dealt in some way with health care. No statistically significant differences were detected between coalitions on health and those on other policy areas with respect to factors such as coalition size, number of leaders, perceived cooperativeness, perceived effectiveness, and founding year, based on a similar data collection strategy. Given these results, we think that it is reasonable to view behavior inside health policy coalitions as representative of behavior inside coalitions focused on other policy domains.

6. Limitations

The differences between Models 1 and 2 in the coefficients on Network Embeddedness and Diversity X Embeddedness suggest that the effects of embeddedness may be contingent on the point at which an interest group first makes a leadership contribution to a coalition. That is, embeddedness may not be an important explanation for why founders provide leadership for a coalition, but they may help to explain why interest groups that subsequently join a coalition become recognized (or not) as leaders within it. This finding indicates that it may be valuable to model simultaneously the decision of an interest group to join a coalition and to contribute leadership to the coalition. Such a model would require a two-stage estimation technique. A limitation of our research is that such an estimator has not yet been derived in the ERGM framework, making it impossible for us to pursue this approach at this point. Developing such an estimator would be a worthy endeavor for future research. This study provides one empirical example of how it could be fruitfully applied.

A second limitation of our study pertains to the measurement of recognized leadership contributions. We measured the contributions of all groups within a coalition using a single
informant for each coalition, usually a coalition coordinator. Doing so requires us to make the assumption that the informants are not systematically biased in favor or against particular interest groups in their coalitions. While we think that this assumption is reasonable, fully evaluating the fixed effects of such bias would require us to estimate statistical models containing 73 dummy variables (for each of N-1 coalitions). We attempted to do so, but such a model does not converge in the ERGM, generalized linear model, or linear mixed-effects model framework. Hence, we leave it to future research to evaluate how such possible respondent biases might influence estimates about the effects of coalition composition. One approach would be to have multiple informants per coalition, though such a strategy would increase the resources required to undertake the study.

7. Conclusions

The results of this study yield strong support for H1a, that an interest group is more likely to contribute effort to a coalition when the coalition has a high degree of partisan diversity, as opposed to a high degree of partisan homogeneity. This effect is robust, holding up in all six specifications of our ERGM. Thus, in an age of partisan polarization, coalitions are likely to have recognized contributions of leadership from more of their members when they cut across partisan lines than when they build entirely within one party or the other.

It is important to note that having more interest groups contribute leadership to a coalition is not necessarily a good thing. More groups trying to steer the coalition could promote infighting that undermines the coalition’s effectiveness. Still, on the positive side, our results clearly demonstrate that coalitions with more partisan diversity get serious attention from more of their members. These are the coalitions that interest groups are more likely to believe affect the policy process, possibly because they have succeeded in brokering across the partisan divide. Since it is hard to work in a bipartisan fashion, these coalitions gain greater notice than their counterparts. This finding has clear implications for coalition building: if the coordinators of a coalition want its
members to contribute actively, they are better off reaching out to allies of all partisan stripes (i.e., strange bedfellows) than in relying on a more homogeneous partisan team (i.e., the usual suspects). Thus, the study contributes to knowledge in the areas of coalitions and diversity.

Our analysis provides mixed support for H2a over H2b; that is, interest groups contribute more to coalitions in which they are closely embedded. This conclusion is sensitive to the specification of the model. The embeddedness effect is positive and significant in Model 2, which does not include the leadership contributions of founding organizations, but not in Model 1, which includes all observed leadership contributions. It is positive and significant in Models 3 and 6, both of which exclude the number of coalitions joined by interest groups, as well as coalition size. It is insignificant in Models 4 and 5, which are specified to include all control variables. Thus, it is possible that there is some effect of embeddedness on the leadership contributions by groups to coalitions, but it is also possible that this effect is conflated by the volume of participation by groups in coalitions. We cannot rule out an embeddedness effect, but our findings do not establish it either.

In all cases where the effect of embeddedness is statistically significant (Models 2, 3, and 6), then the coefficient on the interaction between diversity and embeddedness is negative and significant, favoring H3b over H3a. Thus, if there is an effect of embeddedness, then the results show that it trades off with diversity. That is, if leadership contributions are stimulated in situations where members of a coalition work together frequently in other coalitions, then any concomitant boost that the coalition receives from partisan diversity likely is diminished in magnitude. Conversely, if the coalition has high partisan diversity, then leadership contributions resulting from embeddedness are likely diminished in magnitude. The effects of partisan diversity are in tension with the effects of embeddedness whenever there is evidence that embeddedness effects exist. The implication of these results is that coalition coordinators should weigh carefully the value of coalitions that are both diverse and closely embedded.
Our analysis supports the view that the composition of a coalition affects the willingness of its members to be active, devote effort, and become recognized for contributing leadership to the coalition. Who is on the team makes a difference to how its members work together. It is not enough – as previous studies have done – to focus on the process of joining coalitions. It is also important to examine what happens inside the coalition after it has begun its work. To do so, it is necessary to examine the coalition level of analysis, as we have done. This analysis reveals coalitions as complex organizations in their own right that matter to the unfolding of the policy process. They are more than just the byproduct of strategic calculations made by individual interest groups.

8. References


Mahoney, Christine, and Frank R. Baumgartner. 2015. “Partners in Advocacy.” *Journal of Politics*

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Figure 1. Illustrations of Two-Mode Network with Structural Zeros

A. Matrix Illustration (Hypothetical Cases)

<table>
<thead>
<tr>
<th>Interest Group</th>
<th>Coalition 1</th>
<th>Coalition 2</th>
<th>Coalition 3</th>
<th>Coalition 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>X</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>1</td>
<td>X</td>
<td>1</td>
</tr>
<tr>
<td>D</td>
<td>0</td>
<td>0</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>E</td>
<td>X</td>
<td>0</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>F</td>
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<td>0</td>
<td>1</td>
<td>X</td>
</tr>
<tr>
<td>G</td>
<td>X</td>
<td>X</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>H</td>
<td>1</td>
<td>X</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>I</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>1</td>
</tr>
</tbody>
</table>

B. Graph of Four Coalitions (Actual Cases)

Note:

1 indicates that an interest group is a member of the coalition and is recognized as contributing leadership.
0 indicates that an interest group is a member of the coalition, but is not recognized as contributing leadership.
X indicates that an interest group is neither a member of the coalition nor is recognized as contributing leadership. X represents the “structural zeros”.

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Table 1. Factors Associated with Recognition of Leadership Contributions to Coalitions
(Two-Mode Exponential Random Graph Models with Structural Zeros)

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Mode</th>
<th>Model 1 Coefficient (Standard Error)</th>
<th>Model 2 Coefficient (Standard Error)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Focal Variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partisan Diversity</td>
<td>H1a, H1b</td>
<td>Coalition</td>
<td>0.49 (0.19)**</td>
</tr>
<tr>
<td>Network Embeddedness</td>
<td>H2a, H2b</td>
<td>Interest Group</td>
<td>29.37 (21.65)</td>
</tr>
<tr>
<td>Diversity X Embeddedness</td>
<td>H3a, H3b</td>
<td>Both</td>
<td>-8.55 (5.23)</td>
</tr>
<tr>
<td><strong>Partisanship</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest Group Partisanship</td>
<td>Control</td>
<td>Interest Group</td>
<td>0.02 (0.02)</td>
</tr>
<tr>
<td>Coalition Partisanship</td>
<td>Control</td>
<td>Coalition</td>
<td>0.07 (0.03)*</td>
</tr>
<tr>
<td>Interest Group-Coalition Partisan Differential</td>
<td>Control</td>
<td>Both</td>
<td>-0.01 (0.03)</td>
</tr>
<tr>
<td><strong>Interest Group Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Coalition Memberships</td>
<td>Control</td>
<td>Interest Group</td>
<td>-0.02 (0.02)</td>
</tr>
<tr>
<td>Interest Group Age</td>
<td>Control</td>
<td>Interest Group</td>
<td>0.23 (0.19)</td>
</tr>
<tr>
<td>Citizens Advocacy Group</td>
<td>Control</td>
<td>Interest Group</td>
<td>0.27 (0.15)</td>
</tr>
<tr>
<td>Lobbying Expenditures</td>
<td>Control</td>
<td>Interest Group</td>
<td>-0.00 (0.01)</td>
</tr>
<tr>
<td>Interest Group Crosses Issue Boundary</td>
<td>Control</td>
<td>Interest Group</td>
<td>-0.07 (0.20)</td>
</tr>
<tr>
<td><strong>Coalition Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coalition Size</td>
<td>Control</td>
<td>Coalition</td>
<td>-0.04 (0.01)**</td>
</tr>
<tr>
<td>Coalition Age</td>
<td>Control</td>
<td>Coalition</td>
<td>0.68 (0.65)</td>
</tr>
<tr>
<td>Coalition Dues</td>
<td>Control</td>
<td>Coalition</td>
<td>-0.04 (0.17)</td>
</tr>
<tr>
<td>Coalition Faces Legislative Threat</td>
<td>Control</td>
<td>Coalition</td>
<td>-0.06 (0.22)</td>
</tr>
<tr>
<td>Coalition Focuses on Authorizing Legislation</td>
<td>Control</td>
<td>Coalition</td>
<td>-0.10 (0.18)</td>
</tr>
<tr>
<td>Coalition Steering Committee</td>
<td>Control</td>
<td>Coalition</td>
<td>0.18 (0.16)</td>
</tr>
<tr>
<td><strong>Network Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest Group Mode Two-Stars</td>
<td>Endogenous</td>
<td>Both</td>
<td>0.14 (0.04)**</td>
</tr>
<tr>
<td>Edges</td>
<td>Endogenous</td>
<td>Both</td>
<td>-2.77 (0.87)**</td>
</tr>
</tbody>
</table>

***p ≤ 0.001, **p ≤ 0.01, *p ≤ 0.05.
Figure 2. Goodness-of-Fit Boxplots for Model 1
List of Items in Online Appendix

A 1. List of Interest Groups Included in the Research
A 2. List of Coalitions Included in the Research
A 3. Explanation of Two-Mode Data Structure
A 4. Factors Associated with Recognition of Leadership Contributions to Coalitions, Models 3-6
A 5. Endogenous Goodness-of-Fit Assessment for Models 2-6
A 6. Precision-Recall Curves for Models 1-6
A 7. MCMC Diagnostics
A 8. R Replication Code
A 1. List of Interest Groups Included in the Research

60 Plus Association
AARP
Advanced Medical Technology Association
AFL-CIO
AIDS Action Council
Alliance for Retired Americans
Alzheimer's Association
American Academy of Child and Adolescent Psychiatry
American Academy of Dermatology
American Academy of Family Physicians
American Academy of Orthopaedic Surgeons
American Academy of Otolaryngology – Head and Neck Surgery
American Academy of Pediatrics
American Academy of Physician Assistants
American Association for Dental Research
American Association of Colleges of Nursing
American Association of Colleges of Pharmacy
American Association of Health Plans
American Association of Homes and Services for the Aging
American Association of Nurse Anesthetists
American Bar Association
American Benefits Council
American Cancer Society
American Chiropractic Association
American College of Cardiology
American College of Emergency Physicians
American College of Obstetricians and Gynecologists
American College of Physicians
American College of Preventive Medicine
American College of Surgeons
American Council of Life Insurers
American Dental Association
American Dental Education Association
American Diabetes Association
American Dietetic Association
American Farm Bureau Federation
American Federation for Medical Research
American Federation of Government Employees
American Federation of State, County, and Municipal Employees
American Gastroenterological Association
American Health Care Association
American Health Planning Association
American Health Quality Association
American Heart Association
American Hospital Association
American Insurance Association
American Legion
American Lung Association
American Medical Association
American Nurses Association
American Osteopathic Association
American Pharmacists Association
American Physical Therapy Association
American Psychiatric Association
American Psychological Association
American Public Health Association
American Social Health Association
American Society for Clinical Pathology
American Society for Microbiology
American Society of Anesthesiologists
American Society of Association Executives
American Society of Hematology
American Speech-Language-Hearing Association
Americans for Tax Reform
Arthritis Foundation
Association for the Advancement of Psychology
Association of American Medical Colleges
Association of Minority Health Professions Schools
Association of National Advertisers
Association of Schools of Public Health
Association of State and Territorial Health Officials
Association of Teachers of Preventive Medicine
Association of Trial Lawyers of America
Autism Society of America
Biotechnology Industry Organization
Blue Cross and Blue Shield Association
Business Roundtable
Candlelighters Childhood Cancer Foundation
Children's Defense Fund
Christian Coalition of America
Citizens for Public Action on High Blood Pressure and Cholesterol
Coalition for Health Funding
College of American Pathologists
Common Cause
Concord Coalition
Consumer Federation of America
Cooley's Anemia Foundation
Council for Government Reform
Crohn's and Colitis Foundation of America
Cystic Fibrosis Foundation
Disabled American Veterans
Endocrine Society
Environmental Defense
Epilepsy Foundation
Families USA
Federation of American Hospitals
Federation of American Societies for Experimental Biology
Generic Pharmaceutical Association
Greater New York Hospital Association
Grocery Manufacturers of America
Health Insurance Association of America
Healthcare Distribution Management Association
Healthcare Leadership Council
Human Rights Campaign
Independent Insurance Agents and Brokers of America
International Brotherhood of Teamsters
International Council of Cruise Lines
Joint Commission on Accreditation of Healthcare Organizations
Joint Council of Allergy, Asthma, and Immunology
Juvenile Diabetes Research Foundation International
March of Dimes Birth Defects Foundation
Medical Device Manufacturers Association
Medical Library Association
NARAL Pro-Choice America
National Alliance for Hispanic Health
National Alliance for the Mentally Ill
National Alliance of Breast Cancer Organizations
National Association for Home Care
National Association for the Advancement of Colored People
National Association of Chain Drug Stores
National Association of Children's Hospitals
National Association of Community Health Centers
National Association of Counties
National Association of County and City Health Officials
National Association of Independent Insurers
National Association of Insurance Commissioners
National Association of Manufacturers
National Association of Social Workers
National Association of State Alcohol and Drug Abuse Directors
National Breast Cancer Coalition
National Citizens' Coalition for Nursing Home Reform
National Committee to Preserve Social Security and Medicare
National Conference of State Legislatures
National Council for Community Behavioral Healthcare
National Council of La Raza
National Farmer's Union
National Federation of Independent Business
National Governors Association
National Hemophilia Foundation
National Kidney Foundation
National League for Nursing
National Mental Health Association
National Partnership for Women and Families
National Rehabilitation Association
National Restaurant Association
National Retail Federation
National Right to Life Committee
National Rural Electric Cooperative Association
National Society of Professional Engineers
National Union of Hospital and Health Care Employees / Local 1199
National Urban League
National Women's Health Network
Paralyzed Veterans of America
Parkinson's Action Network
Pharmaceutical Research and Manufacturers of America
Planned Parenthood Federation of America
Public Citizen
Renal Physicians Association
Seniors Coalition
Service Employees International Union
Society for Investigative Dermatology
The Arc of the United States
United Auto Workers
United Cerebral Palsy Associations
United Mine Workers of America
United States Chamber of Commerce
United States Conference of Catholic Bishops
United States Conference of Mayors
Veterans of Foreign Wars
Vietnam Veterans of America
Washington Business Group on Health
A 2. List of Coalitions Included in the Research

Ad Hoc Group for Medical Research Funding
Alliance of Specialty Medicine
Alliance to Improve Medicare
AMA Large Group on "Part B" Issues (Coalition for Payment)
American Tort Reform Association (ATRA)
Americans for Long Term Care Security
Anti-Reimportation Coalition (a fabricated name) *
Antitrust Coalition for Consumer Choice in Health Care
Archer MSA Coalition
Association Health Plan Coalition
Campaign for Quality Care
Campaign for Tobacco Free Kids
CDC Coalition (Centers for Disease Control and Prevention)
Children's Environmental Health Network (CHEN)
Children's Health Group
Citizens for Better Medicare
Citizens for Long-Term Care Coalition
Coalition for Affordable Health Coverage
Coalition for Fair Medicare Payment
Coalition for Fairness in Mental Illness Coverage (Mental Health Parity Coalition)
Coalition for Genetic Fairness
Coalition for Health Funding
Coalition for the Advancement of Medical Research (CAMR)
Coalition on Human Needs
Coalition to Fight Sexually Transmitted Diseases
Confidentiality Coalition
Consortium for Children with Disabilities
Consortium for Citizens with Disabilities (CCD)
Cover the Uninsured Week Coalition
Employers' Coalition on Medicare
Families USA Medicaid Action Coalition
Family Planning Coalition
FamilyCare Act Coalition
Federation of Associations of the Schools of the Health Professions (FASHP)
FMAP Coalition (Federal Medicaid Matching Rate)
Friends of AHRQ (Agency for Health Research and Quality)
Friends of HRSA (Health Resources and Services Administration)
Friends of Indian Health
Friends of NICHD Coalition (National Institute of Child Health and Human Development)
Friends of VA Medical Care and Health Research (FOVA)
 Genetic Alliance
 Genome Action Coalition
 GINE Coalition
 Health Benefits Coalition for Affordable Choice and Quality
 Health Coalition on Liability and Access (HCLA)
 Health Professions and Nursing Education Coalition (HPBEC)
Health Professions Network
Independence Through Enhancement of Medicare and Medicaid Coalition (ITEM)
Independent Budget
Leadership Council on Aging Organizations
Limited English Proficiency Coalition
Long Term Care Campaign
Mental Health Liaison Group
National Alliance for Nutrition and Activity (NANA)
National Coalition on Health Care
National Coalition to Support Sexuality Education
National Colorectal Cancer Roundtable
National Council on Folic Acid
National Council on Patient Information and Education
National Health Council
National Immunization Council
National Medical Liability Reform Coalition
National Organizations Responding to AIDS Coalition (NORA)
National Partnership’s Patients Bill of Rights Coalition
NIAMS Coalition (National Institute of Arthritis and Musculoskeletal & Skin Diseases)
One Voice Against Cancer (OVAC)
Opponents of a Medicare Home Health Copayment (a fabricated name) *
Opponents of Association Health Plans (a fabricated name) *
Partnership for Clear Health Communication
Partnership for Prevention
Patient Access Coalition
Patient Access to Responsible Care Alliance (PARCA)
Pro-Choice Coalition (The Small Lobby)
Research to Prevention
Research!America
Rx Benefits Coalition
Rx Health Value
Smallpox Compensation Coalition
Task force on the NGA Medicaid Task Force
Women's Health Research Coalition

Note. * In three cases, we created the coalition’s name because the participants chose not to assign a formal name to the coalition. Acronyms are listed only if the coalition participants referred to the coalition by the acronym. If the official coalition name contains an acronym, the meaning of the acronym is in parentheses. If the coalition also uses an alternative name, that name is listed in parentheses.
A 3. Explanation of Two-Mode Data Structure

The data structure is nested in the following way. In the membership graph $G = (U, V, E)$, a group $u$ is connected to a coalition $v$ by an edge $e = (u,v)$ if it is a member of this coalition. In the recognized leadership graph, group $u$ is connected to coalition $v$ by edge $e' = (u,v)$ if it is recognized as a leader in the coalition. Therefore, recognized leadership is a proper edge-induced subgraph $G[E']$ of the membership graph with edge set $E' \subseteq E$.

There are $|U| \cdot |V| = 12,654$ observations (or possible edges) in the membership network, $|E| = 1,070$ observations (or possible edges) in the nested recognized leadership network (this is also the number of realized edges in the membership network), and $|E'| = 271$ realized edges in the recognized leadership network. These observations yield a density of $\frac{|E|}{|U| \cdot |V|} = 0.085$ in the membership network and $\frac{|E'|}{|E|} = 0.253$ in the nested recognized leadership subgraph.

The goal of the analysis is to model $G[E']$ (rather than $G$). Two non-standard constraints to the default ERGM definition are necessary. First, we analyze a two-mode network, which does not allow edges within node classes: $\forall e' \in E': (u,u') \notin E', (v,v') \notin E'$. Therefore, $N$ and $N^*$ have dimensions $(|U| + |V|) \times (|U| + |V|)$, but all block-diagonal dyads $N_{u \in U, u' \in U}$ as well as $N_{v \in V, v' \in V}$ are constrained to be zero in any $N^* \in \mathcal{N}$ (so-called structural zeros). This constraint means that we must adjust the size of the sample space to contain only network matrices in which no positive block-diagonal entries are present. Second, since recognized leadership is an edge-induced subgraph of membership, $N^* \in \mathcal{N}$ must never contain any edges which are not contained in the membership graph $G$. Hence, we define the set of possible network topologies as $\mathcal{N} \setminus \tilde{G}$ (rather than $\mathcal{N}$) where $\tilde{G}$ is the set of matrices representing all edge-induced subgraphs of the complement graph $\tilde{G}$ of $G$.

At the estimation stage, this is solved by adding a matrix representing $\tilde{G}$, the complement graph of
the membership network, as an edge covariate to $h(N)$, and by constraining the coefficient corresponding to this covariate in $\theta$ to be infinitely small.

We include a two-star terms in the ERGM in order to control for clustered activity of groups (i.e., recognized leadership in multiple coalitions). The statistic can be expressed as the count

$$h_{\text{twostar}} = \sum_{i<k} \sum_j N_{ij}N_{kj}$$

where $N_{ij} = 1$ if node $j$ has an incoming tie from node $i$ and 0 otherwise. This subgraph product counts the number of local graph configurations where a node has two incoming ties. The two-star statistic is included once for groups (with $j \in U$ and $i, k \in V$) and, in Model Model 6, once for coalitions (with $j \in V$ and $i, k \in U$). The inclusion of these terms accounts for the endogenous nature of network formation.
## A 4. Factors Associated with Recognition of Leadership Contributions to Coalitions, Models 3-6
(Two-Mode Exponential Random Graph Models with Structural Zeros)

<table>
<thead>
<tr>
<th></th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
</tr>
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<tbody>
<tr>
<td><strong>Focal Variables</strong></td>
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<tr>
<td>Partisan Diversity</td>
<td>0.61 (0.17)***</td>
<td>0.50 (0.19)**</td>
<td>0.58 (0.19)**</td>
<td>0.59 (0.18)**</td>
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<tr>
<td>Network Embeddedness</td>
<td>57.59 (19.72)**</td>
<td>29.76 (22.10)</td>
<td>32.98 (21.17)</td>
<td>46.31 (21.48)*</td>
</tr>
<tr>
<td>Diversity X Embeddedness</td>
<td>-15.03 (4.78)**</td>
<td>-8.31 (5.31)</td>
<td>-11.75 (5.11)*</td>
<td>-11.18 (5.22)*</td>
</tr>
<tr>
<td><strong>Partisanship</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Interest Group Partisanship</td>
<td>0.02 (0.02)</td>
<td>0.02 (0.02)</td>
<td>0.02 (0.02)</td>
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</tr>
<tr>
<td>Coalition Partisanship</td>
<td>0.10 (0.04)*</td>
<td>0.06 (0.03)</td>
<td>0.09 (0.03)**</td>
<td></td>
</tr>
<tr>
<td>Interest Group-Coalition Partisan Differential</td>
<td>-0.02 (0.03)</td>
<td>-0.03 (0.03)</td>
<td>-0.01 (0.03)</td>
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<tr>
<td><strong>Interest Group Characteristics</strong></td>
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<td></td>
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</tr>
<tr>
<td>Number of Coalition Memberships</td>
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<td>-0.04 (0.02)</td>
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<tr>
<td>Interest Group Age</td>
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<td>0.27 (0.21)</td>
<td>0.21 (0.19)</td>
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<tr>
<td>Citizens Advocacy Group</td>
<td>0.25 (0.16)</td>
<td>0.33 (0.17)</td>
<td>0.32 (0.16)*</td>
<td></td>
</tr>
<tr>
<td>Lobbying Expenditures</td>
<td>0.00 (0.01)</td>
<td>-0.01 (0.01)</td>
<td>-0.00 (0.01)</td>
<td></td>
</tr>
<tr>
<td>Interest Group Crosses Issue Boundary</td>
<td>-0.09 (0.21)</td>
<td>-0.06 (0.21)</td>
<td>0.02 (0.20)</td>
<td></td>
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<tr>
<td><strong>Coalition Characteristics</strong></td>
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<tr>
<td>Coalition Size</td>
<td>-0.03 (0.01)***</td>
<td>-0.02 (0.01)*</td>
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</tr>
<tr>
<td>Coalition Age</td>
<td>0.57 (0.70)</td>
<td>0.83 (0.67)</td>
<td>0.30 (0.65)</td>
<td></td>
</tr>
<tr>
<td>Coalition Dues</td>
<td>-0.03 (0.18)</td>
<td>-0.17 (0.18)</td>
<td>0.03 (0.17)</td>
<td></td>
</tr>
<tr>
<td>Coalition Faces Legislative Threat</td>
<td>-0.02 (0.22)</td>
<td>-0.04 (0.22)</td>
<td>-0.16 (0.21)</td>
<td></td>
</tr>
<tr>
<td>Coalition Focuses on Authorizing Legislation</td>
<td>-0.14 (0.21)</td>
<td>-0.43 (0.20)*</td>
<td>0.14 (0.18)</td>
<td></td>
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<tr>
<td>Coalition Steering Committee</td>
<td>0.15 (0.17)</td>
<td>0.02 (0.16)</td>
<td>0.07 (0.15)</td>
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<tr>
<td>Coalition Communication Indegree</td>
<td>2.65 (0.42)***</td>
<td></td>
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<td><strong>Coalition Diversity</strong></td>
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<tr>
<td>Age Diversity</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Citizens Advocacy Diversity</td>
<td>-0.22 (0.69)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lobbying Expenditures Diversity</td>
<td>-0.02 (0.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boundary-Crossing Diversity</td>
<td>0.09 (0.58)</td>
<td></td>
<td></td>
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<tr>
<td><strong>Network Characteristics</strong></td>
<td></td>
<td></td>
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<tr>
<td>Interest Group Mode Two-Stars</td>
<td>0.12 (0.02)***</td>
<td>0.14 (0.04)***</td>
<td>0.09 (0.05)*</td>
<td>0.11 (0.03)***</td>
</tr>
<tr>
<td>Coalition Mode Two-Stars</td>
<td></td>
<td>-0.00 (0.03)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edges</td>
<td>-3.82 (0.73)***</td>
<td>-2.34 (1.00)*</td>
<td>-3.87 (0.89)***</td>
<td>-4.30 (0.82)***</td>
</tr>
</tbody>
</table>

*"p ≤ 0.001, "p ≤ 0.01, "p ≤ 0.05."
A 5. Endogenous Goodness-of-Fit Assessment for Models 2-6

Figure A 5.1. Endogenous Goodness of Fit for Model 2
Figure A 5.2. Endogenous Goodness of Fit for Model 3

Non-edge-wise shared partners

Degree (first mode)

Degree (second mode)

Geodesic distances

k-star (first mode)

k-star (second mode)
Figure A 5.3. Endogenous Goodness of Fit for Model 4

Non-edge-wise shared partners

Degree (first mode)

Degree (second mode)

Geodesic distances

k-star (first mode)

k-star (second mode)
Figure A 5.4. Endogenous Goodness of Fit for Model 5
Figure A 5.5. Endogenous Goodness of Fit for Model 6
A 6. Precision-Recall Curves for Models 1-6

We compute precision-recall (PR) curves in order to compare the simulations to the observed leadership network. This step serves to compare the actual location of edges in the graph rather than its network topology. The y axis of a PR curve contains the precision with which edges in the observed network are predicted by the simulations. Large values indicate that only true positive values (realized edges in the observed network) are predicted as edges by the simulations whereas small values indicate that the simulations predict the true positive values but also many false positives, that is, edges that are not actually observed. The x axis contains the recall of the edges. Large values indicate that a large fraction of observed edges are predicted as edges by the model whereas small values indicate that many of the originally observed edges are predicted as non-edges by the model. The more simulations there are, the more points there are on the plane. These points are connected and make up the PR curve. A good model entails large values on both axes and therefore a curve tending toward the upper right corner. A poor model tends toward the lower left corner of the diagram. Figure A 6 plots PR curves for Models 1-6 and a null model containing only the edges term (also known as a Bernoulli random graph model). All models yield a moderate to good explained variance, with an area under the PR curve ranging between 0.46 for Model 5 and 0.20 for Model 2, with a relatively high predictive within-sample performance of Model 1 at an AUC value of 0.43. All models perform considerably better than a random model (AUC-PR = 0.00).
Figure A 6. Precision Recall Curves for Models 1-6
A 7. MCMC Diagnostics

Figure A 7 shows the trace plots of the MCMC chain. In non-degenerate models, the changes to the parameters are stationary. This means that there is no trend over time that leads away from the expected value in the panels on the left, and there is approximately a normal distribution of these changes as shown in the panels on the right. All model terms show acceptable traces.

**Figure A 7. MCMC Diagnostics**
library("network") # tested with version 1.13.0
library("ergm")    # tested with version 3.5.1
library("xergm")   # tested with version 1.7.0 (btergm version 1.7.1)
library("texreg")  # tested with version 1.36.4
library("inline")  # tested with version 0.3.14
library("Rcpp")    # tested with version 0.12.2

burnin <- 10000    # MCMC burnin
sampsize <- 10000  # MCMC sample size
maxit <- 200       # number of MCMC MLE iterations
nsim <- 1000       # number of simulated networks for the GOF assessment
cores <- 4         # number of computing cores for parallel processing
seed <- 1234       # random seed for exact reproducibility
set.seed(seed)

# leadership network
leader <- as.matrix(read.csv("Coalition_Leadership.csv", header = TRUE,
     row.names = 1, stringsAsFactors = FALSE))

# coalition non-membership matrix
nonmem <- as.matrix(read.csv("Coalition_Nonmembership.csv", header = TRUE,
     row.names = 1, stringsAsFactors = FALSE))

# several nodal attributes
attrib <- read.csv("Coalition_Node_Attributes.csv", header = TRUE)

# communication network: any kind of communication
comm.any <- as.matrix(read.table("Communication_Any.csv",
     stringsAsFactors = FALSE, sep = ",", header = TRUE, row.names = 1))

# communication network: occasional communication
comm.occ <- as.matrix(read.table("Communication_Occasional.csv",
     stringsAsFactors = FALSE, sep = ",", header = TRUE, row.names = 1))

# communication network: regular communication
comm.reg <- as.matrix(read.table("Communication_Regular.csv",
     stringsAsFactors = FALSE, sep = ",", header = TRUE, row.names = 1))

mem <- (nonmem * -1) + 1  # membership matrix
nonmem <- network(nonmem, directed = FALSE, bipartite = TRUE)  # create network
leader <- network(leader, directed = FALSE, bipartite = TRUE)  # create network

# attributes contain both groups and coalitions; they need to be separated
attrib.grp <- attrib[1:nrow(mem), ]
attrib.coal <- attrib[(nrow(mem) + 1): nrow(attrib), ]

# who founded which coalition?
founded <- as.matrix(read.csv("Founded.csv", header = TRUE, row.names = 1,
     stringsAsFactors = FALSE))
# Create new model terms for multiplexity and diversity

# H1: membership co-occurrence, communication density, and multiplexity

# impute NA values in communication
for (i in 1:nrow(comm.any)) {
  for (j in 1:ncol(comm.any)) {
    if (is.na(comm.any[i, j]) && !is.na(comm.any[j, i])) {
      comm.any[i, j] <- comm.any[j, i]  # impute from reciprocal dyad
    } else if (is.na(comm.any[j, i])) {
      comm.any[i, j] <- 0  # zero-impute if reciprocal dyad also NA
    }
    if (is.na(comm.reg[i, j]) && !is.na(comm.reg[j, i])) {
      comm.reg[i, j] <- comm.reg[j, i]
    } else if (is.na(comm.reg[j, i])) {
      comm.reg[i, j] <- 0
    }
    if (is.na(comm.occ[i, j]) && !is.na(comm.occ[j, i])) {
      comm.occ[i, j] <- comm.occ[j, i]
    } else if (is.na(comm.occ[j, i])) {
      comm.occ[i, j] <- 0
    }
  }
}

# compute co-occurrence of coalition membership among coalition members
cpp.comember <- cxxfunction(signature(mat = "matrix"), plugin = "Rcpp",
body = 'IntegerMatrix mem = as<IntegerMatrix>(mat);
int rows = mem.nrow();
int cols = mem.ncol();
Rcpp::NumericMatrix comemb = NumericMatrix(rows, cols);
int realized;
int possible;
for (int i = 0; i < cols; i++) {
  realized = 0;
  possible = 0;
  for (int j = 0; j < rows; j++) {
    for (int k = 0; k < rows; k++) {
      for (int l = 0; l < cols; l++) {
        if (j != k && i != l && mem(j, i) == 1 && mem(k, i) == 1) {
          possible++;
          if (mem(k, l) == 1 && mem(j, l) == 1) {
            realized++;
          }
        }
      }  // innermost loop
    }  // next dyad
  }  // for j
  for (int j = 0; j < rows; j++) {
    // std::cout << realized << " " << possible << "\n";
    if (possible == 0.0) {
      comemb(j, i) = 0.0;
    } else {
      comemb(j, i) = double(realized) / double(possible);
    }
  }  // for i
}
return(wrap(comemb));
cpp.commdensity <- function(mat = "matrix", comm = "matrix") {
  IntegerMatrix mem = as<IntegerMatrix>(mat);
  IntegerMatrix com = as<IntegerMatrix>(comm);
  int rows = mem.nrow();
  int cols = mem.ncol();
  Rcpp::NumericMatrix cd = NumericMatrix(rows, cols);
  int realized;
  int possible;
  for (int i = 0; i < cols; i++) {
    realized = 0;
    possible = 0;
    for (int j = 0; j < rows; j++) {
      for (int k = 0; k < rows; k++) {
        if (j != k && mem(j, i) == 1 && mem(k, i) == 1) {
          possible++;
          if (com(j, k) == 1) {
            realized++;
          }
        }
      }
    }
    for (int j = 0; j < rows; j++) {
      // std::cout << realized << " " << possible << "\n";
      if (possible == 0.0) {
        cd(j, i) = 0.0;
      } else {
        cd(j, i) = double(realized) / double(possible);
      }
    }
  }
  return(wrap(cd));
}

Network_Embeddedness <- cpp.comember(mem)

cpp.commdensity <- function(mat = "matrix", comm = "matrix") {
  IntegerMatrix mem = as<IntegerMatrix>(mat);
  IntegerMatrix com = as<IntegerMatrix>(comm);
  int rows = mem.nrow();
  int cols = mem.ncol();
  Rcpp::NumericMatrix cd = NumericMatrix(rows, cols);
  int realized;
  int possible;
  for (int i = 0; i < cols; i++) {
    realized = 0;
    possible = 0;
    for (int j = 0; j < rows; j++) {
      for (int k = 0; k < rows; k++) {
        if (j != k && mem(j, i) == 1 && mem(k, i) == 1) {
          possible++;
          if (com(j, k) == 1) {
            realized++;
          }
        }
      }
    }
    for (int j = 0; j < rows; j++) {
      // std::cout << realized << " " << possible << "\n";
      if (possible == 0.0) {
        cd(j, i) = 0.0;
      } else {
        cd(j, i) = double(realized) / double(possible);
      }
    }
  }
  return(wrap(cd));
}

commdensity <- cpp.commdensity(mem, comm.any)

# H2: diversity

cpp.diversity <- function(mat = "matrix", attribute = "integer") {
  IntegerMatrix mem = as<IntegerMatrix>(mat);
  IntegerVector at = as<IntegerVector>(attribute);
  int rows = mem.nrow();
  int cols = mem.ncol();
  Rcpp::NumericMatrix diversity = NumericMatrix(rows, cols);
  for (int i = 0; i < cols; i++) {
    for (int j = 0; j < rows; j++) {
      double sum = 0.0;
      int counter = 0;
      for (int k = 0; k < rows; k++) {
        if (mem(j, i) == 1 && mem(k, i) == 1) {
          counter++;
          sum = sum + at[k];
        }
      }
      double mean = sum / counter;
    }
  }
  return(wrap(diversity));
}
double sqsum = 0.0;
for (int k = 0; k < rows; k++) {
    if (mem(j, i) == 1 && mem(k, i) == 1) {
        sqsum = sqsum + ((mean - at[k]) * (mean - at[k]));
    }
}
if (counter == 0) {
    diversity(j, i) = 0;
} else {
    diversity(j, i) = sqrt(sqsum / counter);
}
}
return(wrap(diversity));

# diversity measures
Partisan_Diversity <- cpp.diversity(mat = mem,
    attribute = attrib.grp$Conservative_Lean_of_Organization)
diversity.lobspend <- cpp.diversity(mat = mem,
    attribute = attrib.grp$Lobbying_Spending_by_Organization)
diversity.infrep <- cpp.diversity(mat = mem,
    attribute = attrib.grp$Organizations_Influence_Reputation)
diversity.outshealth <- cpp.diversity(mat = mem,
    attribute = attrib.grp$Organization_Identified_Primary_Organization)
diversity.citadv <- cpp.diversity(mat = mem,
    attribute = attrib.grp$Organization_is_Citizens_Advocacy_Organization)
diversity.age <- cpp.diversity(mat = mem,
    attribute = attrib.grp$Years_Since_Founding_of_Organization_Coalition)

# interaction terms comembership * diversity
Diversity_X_Embeddedness <- Network_Embeddedness * Partisan_Diversity
commdensity.diversity <- commdensity * Partisan_Diversity

# modified structural zero offset matrix with 'founded' variable
nonmem2 <- as.matrix(nonmem)
nonmem2[founded == 1] <- 1
sum(mem * founded)  # 136 additional structural zeros
sum((mem * founded) * as.matrix(leader))  # 102 leadership ties are removed

# Create model terms for control variables
# Number_of_Coalition_Memberships: outdegree centrality of groups in the membership network
rs <- rowSums(mem)
Number_of_Coalition_Memberships <- matrix(NA, nrow = nrow(mem),
    ncol = ncol(mem))
for (i in 1:nrow(Number_of_Coalition_Memberships)) {
    Number_of_Coalition_Memberships[i, ] <- rs[i]
}

# Coalition_Size: indegree centrality of coalitions in the membership network
cs <- colSums(mem)
Coalition_Size <- matrix(NA, nrow = nrow(mem), ncol = ncol(mem))
for (i in 1:ncol(Coalition_Size)) {
    Coalition_Size[, i] <- cs[i]
}

# commpart.indeg: indegree centrality in the communication network; count number
# of comm. partners in same coal. and divide by num. of coal. members excl. ego
# (notes: NAs need to be replaced first; the matrix is transposed, i.e.,
# communication flows from columns to rows, so this needs to be transposed)
for (i in 1:nrow(comm.any)) {
  for (j in 1:ncol(comm.any)) {
    if (is.na(comm.any[i, j]) && !is.na(comm.any[j, i])) {
      comm.any[i, j] <- comm.any[j, i]  # impute from reciprocal dyad
    } else if (is.na(comm.any[j, i])) {
      comm.any[i, j] <- 0  # zero-impute if reciprocal dyad also NA
    }
    if (is.na(comm.reg[i, j]) && !is.na(comm.reg[j, i])) {
      comm.reg[i, j] <- comm.reg[j, i]
    } else if (is.na(comm.reg[j, i])) {
      comm.reg[i, j] <- 0
    }
    if (is.na(comm.occ[i, j]) && !is.na(comm.occ[j, i])) {
      comm.occ[i, j] <- comm.occ[j, i]
    } else if (is.na(comm.occ[j, i])) {
      comm.occ[i, j] <- 0
    }
  }
}
commpart.outdeg.any <- matrix(0, nrow = nrow(mem), ncol = ncol(mem))  # any com.
commpart.indeg.any <- commpart.outdeg.any  # indegree, any type of communication
commpart.outdeg.reg <- commpart.outdeg.any  # outdegree, regular communication
commpart.indeg.reg <- commpart.outdeg.any  # indegree, regular communication
for (i in 1:nrow(mem)) {
  for (j in 1:ncol(mem)) {
    if (mem[i, j] == 1) {
      members <- which(mem[, j] == 1)  # all members of this coalition
      # any communication
      comm.subset <- comm.any[members, members]  # comm. partners in this coal.
      groupi <- which(rownames(comm.subset) == rownames(mem)[i])
      indeg.coal <- sum(comm.subset[groupi, ])  # indegree of group i in coal.
      commpart.indeg.any[i, j] <- indeg.coal / (sum(mem[, j]) - 1)
      outdeg.coal <- sum(comm.subset[, groupi])  # outdegree of group i in coal.
      commpart.outdeg.any[i, j] <- outdeg.coal / (sum(mem[, j]) - 1)
      # regular communication
      comm.subset <- comm.reg[members, members]  # comm. partners in this coal.
      groupi <- which(rownames(comm.subset) == rownames(mem)[i])
      indeg.coal <- sum(comm.subset[groupi, ])  # indegree of group i in coal.
      commpart.indeg.reg[i, j] <- indeg.coal / (sum(mem[, j]) - 1)
      outdeg.coal <- sum(comm.subset[, groupi])  # outdegree of group i in coal.
      commpart.outdeg.reg[i, j] <- outdeg.coal / (sum(mem[, j]) - 1)
    }
  }
}
# Interest_Group_Coalition_Partisan_Differential: absolute difference in
# conservatism group vs. coalition
# set the node attribute for re-use with the absdiff term
set.vertex.attribute(leader, "Partisanship",
  attrib$Conservative_Lean_of_Organization_Coalition)
Interest_Group_Coalition_Partisan_Differential <- matrix(NA,
  nrow = nrow(as.matrix(leader)), ncol = ncol(as.matrix(leader))))
cl <- attrib$Conservative_Lean_of_Organization_Coalition
c1.ig <- cl[1:nrow(as.matrix(leader))]
63
cl.coal <- cl[(nrow(as.matrix(leader)) + 1):length(cl)]
for (i in 1:length(cl.ig)) {
  for (j in 1:length(cl.coal)) {
    Interest_Group_Coalition_Partisan_Differential[i, j] <- abs(cl.ig[i] - cl.coal[j])
  }
}

# Interest_Group_Partisanship: conservatism of the group
Interest_Group_Partisanship <- matrix(NA, nrow = nrow(mem), ncol = ncol(mem))
for (i in 1:ncol(mem)) {
  Interest_Group_Partisanship[, i] <- attrib.grp$Conservative_Lean_of_Organization_Coalition
}

# Coalition_Partisanship: conservatism of the coalition
Coalition_Partisanship <- matrix(NA, nrow = nrow(mem), ncol = ncol(mem))
for (i in 1:nrow(mem)) {
  Coalition_Partisanship[i, ] <- attrib.coal$Conservative_Lean_of_Organization_Coalition
}

# Lobbying_Expenditures: lobbying expenditure of organization
Lobbying_Expenditures <- matrix(NA, nrow = nrow(mem), ncol = ncol(mem))
for (i in 1:nrow(mem)) {
  Lobbying_Expenditures[, i] <- attrib.grp$Lobbying_Spending_by_Organization
}

# Coalition_Dues: does the coalition collect dues?
Coalition_Dues <- matrix(NA, nrow = nrow(mem), ncol = ncol(mem))
for (i in 1:nrow(mem)) {
  Coalition_Dues[i, ] <- attrib.coal$Coalition_Collects_Dues
}

# Coalition_Faces_Legislative_Threat: coalition responding to legislative threat
Coalition_Faces_Legislative_Threat <- matrix(NA, nrow = nrow(mem), ncol = ncol(mem))
for (i in 1:nrow(mem)) {
  Coalition_Faces_Legislative_Threat[i, ] <- attrib.coal$Coalition_Responding_to_Legislative_Threat
}

# Coalition_Focuses_on_Authorizing_Legislation
Coalition_Focuses_on_Authorizing_Legislation <- matrix(NA, nrow = nrow(mem), ncol = ncol(mem))
for (i in 1:nrow(mem)) {
  Coalition_Focuses_on_Authorizing_Legislation[i, ] <- attrib.coal$Coalition_Focuses_on_Authorizing_Legislation
}

# Interest_Group_Crosses_Issue_Boundary:
# organization primarily active outside health domain
Interest_Group_Crosses_Issue_Boundary <- matrix(NA, nrow = nrow(mem), ncol = ncol(mem))
for (i in 1:ncol(mem)) {
  Interest_Group_Crosses_Issue_Boundary[, i] <- attrib.grp$Organization_Identified_Primarily_Outside_Health
}

# Citizens_Advocacy_Group: organization is citizens' advocacy organization
Citizens_Advocacy_Group <- matrix(NA, nrow = nrow(mem), ncol = ncol(mem))
for (i in 1:ncol(mem)) {
  Citizens_Advocacy_Group[, i] <-
attrib.grp$Organization_is_Citizens_Advocacy_Organization
}

# Coalition_Steering_Committee: coalition has a steering committee
Coalition_Steering_Committee <- matrix(NA, nrow = nrow(mem), ncol = ncol(mem))
for (i in 1:nrow(mem)) {
  Coalition_Steering_Committee[i,] <-
  attrib.coal$Coalition_Has_Steering_Committee
}

# Interest_Group_Age: centuries since organization was founded
Interest_Group_Age <- matrix(NA, nrow = nrow(mem), ncol = ncol(mem))
for (i in 1:ncol(mem)) {
  Interest_Group_Age[,i] <- 0.01 *
  attrib.grp$Years_Since_Founding_of_Organization_Coalition
}

# Coalition_Age: centuries since coalition was founded
Coalition_Age <- matrix(NA, nrow = nrow(mem), ncol = ncol(mem))
for (i in 1:nrow(mem)) {
  Coalition_Age[i,] <- 0.01 *
  attrib.coal$Years_Since_Founding_of_Organization_Coalition
}

# Estimate ERGMs
# Estimate ERGMs

model.1 <- ergm(
  leader ~
  + edges
  # main effects
  + edgécov(Partisan_Diversity)
  + edgécov(Network_Embeddedness)
  + edgécov(Diversity_X_Embeddedness)
  # controls
  + blstar(2)
  + edgécov(Interest_Group_Coalition_Partisan_Differential)
  + edgécov(Number_of_Coalition_Memberships)
  + edgécov(Coalition_Size)
  + edgécov(Interest_Group_Partisanship)
  + edgécov(Coalition_Partisanship)
  + edgécov(Interest_Group_Age)
  + edgécov(Coalition_Age)
  + edgécov(Citizens_Advocacy_Group)
  + edgécov(Coalition_Dues)
  + edgécov(Lobbying_Expenditures)
  + edgécov(Interest_Group_Crosses_Issue_Boundary)
  + edgécov(Coalition_Faces_Legislative_Threat)
  + edgécov(Coalition_Focuses_on_Authorizing_Legislation)
  + edgécov(Coalition_Steering_Committee)
  + offset(edgécov(nonmem)),
  offset.coef = -Inf, eval.loglik = FALSE,
  control = control.ergm(MCMC.burnin = burnin, MCMC.samplesize = sampsize,
                         seed = seed, MCMLE.maxit = maxit)
)

model.2 <- ergm(
  leader ~
  + edges
  # main effects
  + edgécov(Partisan_Diversity)
+ edgecov(Network_Embeddedness)
+ edgecov(Diversity_X_Embeddedness)
# controls
+ blstar(2)
+ edgecov(Interest_Group_Coalition_Partisan_Differential)
+ edgecov(Number_of_Coalition_Memberships)
+ edgecov(Coalition_Size)
+ edgecov(Interest_Group_Partisanship)
+ edgecov(Coalition_Partisanship)
+ edgecov(Interest_Group_Age)
+ edgecov(Coalition_Age)
+ edgecov(Citizens_Advocacy_Group)
+ edgecov(Coalition_Dues)
+ edgecov(Lobbying_Expenditures)
+ edgecov(Interest_Group_Crosses_Issue_Boundary)
+ edgecov(Coalition_Faces_Legislative_Threat)
+ edgecov(Coalition_Focuses_on_Authorizing_Legislation)
+ edgecov(Coalition_Steering_Committee)
+ offset(edgecov(nonmem2)),
  offset.coef = -Inf, eval.loglik = FALSE,
  control = control.ergm(MCMC.burnin = burnin, MCMC.samplesize = sampsize,
                      seed = seed, MCMLE.maxit = maxit)
)

htmlreg(list(model.1, model.2), single.row = TRUE, omit.coef = "nonmem",
  file = "Models 1-2.html")

# model 3: only main effects and endogenous model terms
model.3 <- ergm(
  leader ~
  + edges
  # main effects
  + edgecov(Partisan_Diversity)
  + edgecov(Network_Embeddedness)
  + edgecov(Diversity_X_Embeddedness)
  # controls
  + blstar(2)
  + offset(edgecov(nonmem)),
    offset.coef = -Inf, eval.loglik = FALSE,
    control = control.ergm(MCMC.burnin = burnin, MCMC.samplesize = sampsize,
                      seed = seed, MCMLE.maxit = maxit)
)

# model 4: add five other diversity variables to model 1
model.4 <- ergm(
  leader ~
  + edges
  # main effects
  + edgecov(Partisan_Diversity)
  + edgecov(Network_Embeddedness)
  + edgecov(Diversity_X_Embeddedness)
  + edgecov(diversity.age)
  + edgecov(diversity.lobspend)
  + edgecov(diversity.citadv)
  + edgecov(diversity.outshealth)
  # controls
  + blstar(2)
  + edgecov(Interest_Group_Coalition_Partisan_Differential)
  + edgecov(Number_of_Coalition_Memberships)
  + edgecov(Coalition_Size)
  + edgecov(Interest_Group_Partisanship)
  + edgecov(Coalition_Partisanship)
  + edgecov(Interest_Group_Age)
)
\begin{verbatim}
+ edgescov(Coalition_Age)
+ edgescov(Citizens_Advocacy_Group)
+ edgescov(Coalition_Dues)
+ edgescov(Lobbying_Expenditures)
+ edgescov(Interest_Group_Crosses_Issue_Boundary)
+ edgescov(Coalition_Faces_Legislative_Threat)
+ edgescov(Coalition_Focuses_on_Authorizing_Legislation)
+ edgescov(Coalition_Steering_Committee)
+ offset(edgescov(nonmem)),
  offset.coef = -Inf, eval.loglik = FALSE,
  control = control.ergm(MCMC.burnin = burnin, MCMC.samplesize = sampsize,
                        seed = seed, MCMLE.maxit = maxit)
)

# model 5: what if we control for ego's communication centrality inside coal?
model.5 <- ergm(
  leader ~
  + edges
  # main effects
  + edgescov(Partisan_Diversity)
  + edgescov(Network_Embeddedness)
  + edgescov(Diversity_X_Embeddedness)
  # controls
  + b1star(2)
  + edgescov(Interest_Group_Coalition_Partisan_Differential)
  + edgescov(Number_of_Coalition_Memberships)
  + edgescov(Coalition_Size)
  + edgescov(Interest_Group_Coalition_Partisanship)
  + edgescov(Coalition_Partisanship)
  + edgescov(Coalition_Age)
  + edgescov(Coalition_Dues)
  + edgescov(Lobbying_Expenditures)
  + edgescov(Interest_Group_Crosses_Issue_Boundary)
  + edgescov(Coalition_Faces_Legislative_Threat)
  + edgescov(Coalition_Focuses_on_Authorizing_Legislation)
  + edgescov(Coalition_Steering_Committee)
  + edgescov(compart.indeg.any)
  + offset(edgescov(nonmem)),
  offset.coef = -Inf, eval.loglik = FALSE,
  control = control.ergm(MCMC.burnin = burnin, MCMC.samplesize = sampsize,
                        seed = seed, MCMLE.maxit = maxit)
)

model.6 <- ergm(
  leader ~
  + edges
  # main effects
  + edgescov(Partisan_Diversity)
  + edgescov(Network_Embeddedness)
  + edgescov(Diversity_X_Embeddedness)
  # controls
  + b1star(2)
  + b2star(2)
  + edgescov(Interest_Group_Coalition_Partisan_Differential)
  + edgescov(Interest_Group_Partisanship)
  + edgescov(Coalition_Partisanship)
  + edgescov(Coalition_Age)
  + edgescov(Coalition_Dues)
  + edgescov(Lobbying_Expenditures)
\end{verbatim}
+ edgecov(Interest_Group_Crosses_Issue_Boundary)
+ edgecov(Coalition_Faces_Legislative_Threat)
+ edgecov(Coalition_Focuses_on_Authorizing_Legislation)
+ edgecov(Coalition_Steering_Committee)
+ offset(edgecov(nonmem)),
  offset.coef = -Inf, eval.loglik = FALSE,
  control = control.ergm(MCMC.burnin = burnin, MCMC.samplesize = sampsize,
    seed = seed, MCMLE.maxit = maxit)

htmlreg(list(model.3, model.4, model.5, model.6), single.row = TRUE,
  custom.model.names = paste("Model", 3:6),
  omit.coef = "nonmem", file = "Models 3-6.html")

# Assess goodness of fit
# ==============================================================================
# boxplot diagrams
go.1 <- gof(model.1, nsim = nsim, statistics = c(nsp, b1deg, b2deg, geodesic,
  blstar, b2star, pr), ncpus = cores, parallel = "multicore")
temp <- gof.1[1:6]
class(temp) <- "gof"
pdf("gof.1.pdf", width = 9, height = 6)
plot(temp)
dev.off()

go.2 <- gof(model.2, nsim = nsim, statistics = c(nsp, b1deg, b2deg, geodesic,
  blstar, b2star, pr), ncpus = cores, parallel = "multicore")
temp <- gof.2[1:6]
class(temp) <- "gof"
pdf("gof.2.pdf", width = 9, height = 6)
plot(temp)
dev.off()

go.3 <- gof(model.3, nsim = nsim, statistics = c(nsp, b1deg, b2deg, geodesic,
  blstar, b2star, pr), ncpus = cores, parallel = "multicore")
temp <- gof.3[1:6]
class(temp) <- "gof"
pdf("gof.3.pdf", width = 9, height = 6)
plot(temp)
dev.off()

go.4 <- gof(model.4, nsim = nsim, statistics = c(nsp, b1deg, b2deg, geodesic,
  blstar, b2star, pr), ncpus = cores, parallel = "multicore")
temp <- gof.4[1:6]
class(temp) <- "gof"
pdf("gof.4.pdf", width = 9, height = 6)
plot(temp)
dev.off()

go.5 <- gof(model.5, nsim = nsim, statistics = c(nsp, b1deg, b2deg, geodesic,
  blstar, b2star, pr), ncpus = cores, parallel = "multicore")
temp <- gof.5[1:6]
class(temp) <- "gof"
pdf("gof.5.pdf", width = 9, height = 6)
plot(temp)
dev.off()

go.6 <- gof(model.6, nsim = nsim, statistics = c(nsp, b1deg, b2deg, geodesic,
  blstar, b2star, pr), ncpus = cores, parallel = "multicore")
temp <- gof.6[1:6]
```r
class(temp) <- "gof"
pdf("gof.6.pdf", width = 9, height = 6)
plot(temp)
dev.off()

# precision-recall curves
gof.1[[7]]$auc.pr  # 0.4325981
gof.2[[7]]$auc.pr  # 0.2001573
gof.3[[7]]$auc.pr  # 0.3232533
gof.4[[7]]$auc.pr  # 0.4078525
gof.5[[7]]$auc.pr  # 0.4627737
gof.6[[7]]$auc.pr  # 0.3804492
pdf("pr.pdf")
plot(gof.2[[7]], col = "red", rgraph = FALSE)
plot(gof.3[[7]], col = "green", rgraph = FALSE, add = TRUE)
plot(gof.4[[7]], col = "orange", rgraph = FALSE, add = TRUE)
plot(gof.5[[7]], col = "cyan", rgraph = FALSE, add = TRUE)
plot(gof.6[[7]], col = "blue", rgraph = FALSE, add = TRUE)
plot(gof.1[[7]], col = "black", rgraph = TRUE, col.rgraph = "gray", add = TRUE)
legend("topright", legend = c("Model 1", "Model 2", "Model 3", "Model 4",
    "Model 5", "Model 6", "Random graph"), col = c("black", "red", "green",
    "orange", "cyan", "blue", "gray"), lty = 1, lwd = 3)
dev.off()

# MCMC trace plots
pdf("mcmcdiag.pdf")
mcmc.diagnostics(model.1)
dev.off()

# save all models and GOF objects to a file
save(model.1, model.2, model.3, model.4, model.5, model.6, gof.1, gof.2, gof.3,
gof.4, gof.5, gof.6, file = "leadership-lobbying.RData")
# load("leadership-lobbying.RData")

# Estimate a random or fixed effects model

rows <- nrow(as.matrix(leader))
cols <- ncol(as.matrix(leader))
ig <- matrix(rep(1:rows, cols), nrow = rows)
coal <- matrix(rep(1:cols, rows), ncol = cols, byrow = TRUE)

# create data frame
nm <- as.matrix(nonmem)
dat <- data.frame(
    leader = as.matrix(leader)[nm != 1],
    absdiff = Interest_Group_Coalition_Partisan_Differential[nm != 1],
    Partisan_Diversity = Partisan_Diversity[nm != 1],
    Network_Embeddedness = Network_Embeddedness[nm != 1],
    Diversity_X_Embeddedness = Diversity_X_Embeddedness[nm != 1],
    Interest_Group_Partisanship = Interest_Group_Partisanship[nm != 1],
    Coalition_Partisanship = Coalition_Partisanship[nm != 1],
    Interest_Group_Age = Interest_Group_Age[nm != 1],
    Coalition_Age = Coalition_Age[nm != 1],
    Citizens_Advocacy_Group = Citizens_Advocacy_Group[nm != 1],
    Coalition_Dues = Coalition_Dues[nm != 1],
    Lobbying_Expenditures = Lobbying_Expenditures[nm != 1],
    Interest_Group_Crosses_Issue_Boundary =
        Interest_Group_Crosses_Issue_Boundary[nm != 1],
    Coalition_Faces_Legislative_Threat = Coalition_Faces_Legislative_Threat[nm != 1],
)
```
dat$coal2 <- factor(dat$coal)  # fixed effect: create factor

# random effect in lme4: estimation does not converge
library("lme4")
model.7 <- glmer(
  leader 
  ~ absdiff
  + Partisan_Diversity
  + Network_Embeddedness
  + Diversity_X_Embeddedness
  + Interest_Group_Partisanship
  + Coalition_Partisanship
  + Interest_Group_Age
  + Coalition_Age
  + Citizens_Advocacy_Group
  + Coalition_Dues
  + Lobbying_Expenditures
  + Interest_Group_Crosses_Issue_Boundary
  + Coalition_Faces_Legislative_Threat
  + Coalition_Focuses_on_Authorizing_Legislation
  + Coalition_Steering_Committee
  + (1 | coal),
  data = dat, family = binomial, nAGQ = 10
)
summary(model.7)

# random effect with glmmPQL: estimation converges, but don't trust the results;
# e.g., no model fit is reported... did it really converge?
library("MASS")
model.7 <- glmmPQL(
  leader 
  ~ absdiff
  + Partisan_Diversity
  + Network_Embeddedness
  + Diversity_X_Embeddedness
  + Interest_Group_Partisanship
  + Coalition_Partisanship
  + Interest_Group_Age
  + Coalition_Age
  + Citizens_Advocacy_Group
  + Coalition_Dues
  + Lobbying_Expenditures
  + Interest_Group_Crosses_Issue_Boundary
  + Coalition_Faces_Legislative_Threat
  + Coalition_Focuses_on_Authorizing_Legislation
  + Coalition_Steering_Committee
  , random = ~ 1|coal,
  , data = dat, family = binomial
)
summary(model.7)

# use GLM and fixed effect: model does not converge
model.7 <- glm(
  leader
  ~ absdiff
  + Partisan_Diversity
  + Network_Embeddedness
+ Diversity_X_Embeddedness
+ Interest_Group_Partisanship
+ Coalition_Partisanship
+ Interest_Group_Age
+ Coalition_Age
+ Citizens_Advocacy_Group
+ Coalition_Dues
+ Lobbying_Expenditures
+ Interest_Group_Crosses_Issue_Boundary
+ Coalition_Faces_Legislative_Threat
+ Coalition_Focuses_on_Authorizing_Legislation
+ Coalition_Steering_Committee
+ coal2
, data = dat, family = binomial
)
summary(model.7)