Passing the Bucks:
Partisan contribution networks and theories of congressional organization

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Abstract

To what extent are parties internally divided along ideological lines? Parties in the United States provide selective incentives to encourage legislators to contribute to the campaigns of their co-partisans, but are these incentives strong enough to offset the tendency to give to ideologically similar colleagues? To answer this question, which has important implications for our understanding of legislative politics and party organization in contemporary American politics, we conduct the first social network analysis of campaign committee and leadership political action committee contributions among members of Congress. Using contributions made during the 1986 to 2006 congressional election cycles, we demonstrate that party contribution networks in Congress do not exhibit higher levels of modularity within ideological clusters of legislators than we would expect by chance alone. This finding implies that members of congressional parties behave in a fairly unified manner: as a group, they do not overly target their contributions toward like-minded co-partisans at the expense of collective electoral efforts to acquire and maintain majority status. By contrast, the largest communities found using an automated community detection algorithm, which tend to have higher levels of modularity, are rarely ideologically divided.

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Beginning in the 1960s, the leaders of political parties in the United States lost their *de facto* control over access to political office. For the first time, political candidates could mount effective campaigns without the resources and campaign organization provided by the Democratic and Republican parties. As a result, elected officials came to assume responsibility for their own re-election (King 1997) and parties evolved to fill a role that Aldrich (1995, 2011) describes as a "party in service to its candidates." With this newfound responsibility has come a kind of freedom; elected officials are now more likely to be motivated by policy or ideological goals than pure partisan allegiance. However, the parties remain vibrant forces in electoral and legislative politics. Indeed, despite these increased incentives for legislators to act in a self-interested or ideological manner, contemporary parties have been remarkably successful at inducing them to contribute toward shared electoral goals.

The growth in campaign contributions among members of Congress is a particularly striking example of how party members voluntarily contribute toward common electoral objectives (in particular, acquiring/maintaining majority status). Members of Congress now play an active role in financing the elections of their colleagues. For instance, members of the 109th House of Representatives of 2005–2006 received more than $15 million directly from the campaign committees and the political action committees of their colleagues (or leadership PACs) during the 2004 election cycle — up from just $1.6 million among winning House candidates in the 1992 cycle.[1] Recently, scholars have begun to more closely examine the role of factors such as electoral competitiveness (Wilcox 1989; Wilcox and Genest 1991; Kanthak 2007; Currinder 2008; Heberlig and Larson 2010; Herrnson 2009) and ideological proximity (Currinder 2003; Kanthak 2007; Kanthak and Krause 2010) in the contributions made between members of Congress.

However, individual- and dyadic- level contribution data may conceal insights about

[1] This more than ninefold increase in member-to-member giving between the 1992 and 2004 electoral cycles vastly outstripped growth in total campaign spending during that time (spending by winning House candidates increased by only 87% in nominal dollars over the same period). Total member-to-member giving during the 2004 cycle represented approximately 3% of the $451.7 million spent by winning House candidates in that cycle (Ornstein, Mann, and Malbin 2009).

the meso- and macro-level structure of parties in Congress, especially given the competing motivations for giving that have been identified in the literature. We therefore examine the overall pattern of member-to-member contributions to understand the nature of cooperative and factional behavior within parties. Specifically, does partisan contribution behavior indicate that the parties are divided into competing ideological factions? Or do parties overcome the ideological, parochial, and individual concerns of members and foster cooperation toward the shared electoral goal of acquiring and maintaining majority status in their chamber?

Previous analyses find that legislators are more likely to receive contributions from ideologically proximate members (Currinder 2003; Kanthak 2007; Kanthak and Krause 2010). However, we argue that these individual-level biases in contributions do not regularly produce factional schisms that would prove damaging to the party's collective goals. Instead, the rewards that parties provide to contributors, which include desirable institutional positions and distributive benefits for constituents, function as selective incentives that encourage members to cooperate toward the party's shared goals and give broadly across ideological lines. Consistent with partisan theories of legislative organization, we expect that these incentives will help produce a pattern of campaign contributions among members across ideological lines.

We analyze contributions between legislators as a social network—a novel approach in the literature on Congress. Previous studies of congressional social networks have largely been confined to linkages that are formed within the legislative process such as shared committee and caucus memberships (Porter et al. 2005, 2007; Victor and Ringe 2009), floor seating proximity (Cohen and Malloy 2011), and bill cosponsorship (Fowler 2006a,b; Zhang et al. 2008; Cho and Fowler 2010), neglecting the other ways in which legislators form ties to each other.[2] We begin our empirical analysis by replicating previous findings showing rapid growth in campaign contributions among members of Congress, which is inconsistent with theories of legislators as single-minded seekers of re-election.

[2]For a notable exception, see Cohen and Malloy (2011), which examines the effects of alumni network ties on Congressional voting.

We then test for the presence of ideological factions using the social network measure of modularity, which allows us to assess the extent to which campaign and leadership PAC contributions are made between ideologically similar members of Congress.

Our results provide support for partisan theories of congressional organization: relative to appropriate statistical baselines, we find that parties exhibit minimal ideological factionalism in their member-to-member contribution networks—legislators frequently make contributions across ideological lines. By contrast, the internal groupings that we recover using an automated community detection algorithm, which show higher levels of modularity, provide little evidence of ideological clustering. In this way, we link the literatures on campaign contributions in Congress and congressional networks with theories of party structure and organization in the legislature.

The internal organization of congressional parties

Congressional parties must somehow induce their members to contribute resources to support co-partisans rather than free-riding on the contributions of others. How do they accomplish this? And how do they prevent members from forming ideological factions that hinder the party's joint efforts to acquire and maintain majority control of the legislature? Consistent with partisan theories of legislative organization, we argue that parties use selective incentives to encourage support for co-partisans across ideological lines—a prediction that contrasts with expectations under majoritarian theories of legislative organization.

As individuals, members of Congress have their own goals: they want to get re-elected, achieve ideological goals with legislation, and attain positions of power and prestige within the legislature (Fenno 1973). Partisan theories of congressional organization hold that these ambitions are channeled by parties to facilitate cooperation toward shared objectives. In particular, Aldrich (1995) argues that parties exist to help members achieve their individual goals by organizing them into a team and coordinating their behavior. As a team,

the members of a congressional party have collective goals which are completely shared by each member (majority control of the chamber), collective goals which are widely but not completely shared (such as ideological policy objectives), personal goals that do not conflict (re-election), and personal goals that do conflict (ambitions over legislative posts, leadership positions, and higher office).

Parties must negotiate conflicts between their members and solve the collective action problems necessary to achieve their shared goals. First, to the extent that members of a party receive benefits from majority control, gaining or retaining majority party control of their legislative chamber is a public good. These benefits include distributional benefits for districts (Engstrom and Vanberg 2010), more prestigious positions for members in the committee system, and increased contributions from outside interest groups (Cox and Magar 1999). Second, parties can affect policy outcomes. While majoritarian theories of Congress typically ignore parties,[3] partisan theories argue that majority parties are able (under certain conditions) to use their institutional powers to shift policy outcomes toward the middle of their parties (Aldrich 1995; Cox and McCubbins 1994, 2005; Rohde 1991).

To accomplish these goals, parties must acquire and retain control of a legislative chamber. Working as a team toward chamber control implies solving collective action problems involved in raising resources for candidates facing difficult elections. Congressional campaigns are incredibly expensive and require extensive fundraising on behalf of vulnerable incumbents and promising challengers. Raising the necessary funds for these campaigns is a difficult task, especially since politicians seem to particularly dislike the process (see, e.g., Jacobson 1980 and the lengthy list of complaints in the first footnote of Blasi 1994).[4]

Congressional parties must therefore induce their members to contribute resources to support co-partisans rather than free-riding on the contributions of others. How do they

[3]They often assume instead that legislative outcomes are chosen by the median voter in the House and by the cloture pivot in the Senate. See, e.g., Krehbiel (1998).

[4]Members of Congress prove to be particularly quotable airing their grievances over fundraising. One anonymous member of Congress recently expressed his feelings about raising money this way: "How much do I like doing it? I hate it. It's the worst…I hate fundraising. I make no bones about it" (Isenstadt and Hohmann 2010). To cope with this repugnant task, members have been encouraged to "learn how to beg, and do it in a way that leaves you with some dignity" (Granat 1984).)

accomplish this? One way is by providing institutional rewards to members who share resources with other members (Kanthak 2007). While members frequently provide contributions to other members for purely self-interested reasons (as a means of acquiring legislative influence, support for leadership positions, etc.), contemporary parties also use contributions between members as an exchange mechanism to allocate legislative power, leadership authority, and campaign resources. Contributors to other legislators are more likely to receive prestigious committee assignments (Heberlig 2003; Cann and Sidman 2011), to advance within the party hierarchy (Heberlig and Larson 2005; Heberlig, Hetherington, and Larson 2006; Cann 2008a,b), and to receive distributive benefits for their districts (Cann and Sidman 2011). Legislators are frequently rewarded for assisting partisan efforts and punished for failing to meet those responsibilities (Cox and McCubbins 1993; Aldrich and Rohde 2000). In particular, the "partisan exchange theory" of Cann (2008b) describes how parties use institutional incentives to encourage members with surplus funds to contribute resources and induce members who need resources to support the party's legislative efforts.

However, not all accounts of congressional behavior posit such a strong role for parties. Member-to-member campaign contributions can therefore provide an important test case for the theoretical debate over congressional organization (see also Cann 2008b). Partisan and majoritarian theories predict different patterns of contributions between members: partisan theories imply that members' contributions to their colleagues express individual goals tempered by the incentives generated by their party, but majoritarian theories suggest contributions will be based on members' individual goals alone. Under majoritarian theory, the only reason to provide a contribution to another member is to advance one's own preferences by affecting the composition of the chamber and its resulting ideological balance. When aggregated to the network level, majoritarian theories suggest that individual behavior will produce a network beset by ideological factions while partisan theories suggest that parties will use selective incentives to induce broader patterns of cooperation.

These accounts cannot be easily disentangled using individual-level data. Previous

analyses find that legislators are more likely to receive contributions from ideologically proximate members (Currinder 2003; Kanthak 2007; Kanthak and Krause 2010), but that they are also likely to receive contributions when they face competitive re-election campaigns (Kanthak 2007; Currinder 2008; Heberlig and Larson 2010). Which tendency dominates at the aggregate level? If patterns of giving are clustered by ideology, the result could be the formation of factions within the party that would inhibit cooperation and produce internal conflict. Likewise, the fact that prolific givers are more likely to be selected as committee chairs and party leaders (Heberlig, Hetherington, and Larson 2006; Cann 2008a) does not tell us how widely those funds are distributed between party moderates, the ideological center of the party, and its extremists. Relatively high contribution totals could be amassed by members who only support colleagues within a given faction of the party or otherwise fail to contribute to shared electoral goals (e.g., by failing to provide contributions to candidates facing competitive elections). We therefore turn to social network analysis to better characterize the presence or absence of ideological factions in member-to-member giving. The next section more precisely characterizes our network measures and our empirical hypotheses.

Methods and hypotheses

We use member-to-member contribution networks to examine ideological divisions within the parties in Congress. Social network analysis allows us to analyze factionalization in member-to-member giving in Congress using a different approach than previous individual- and dyad-level studies of member contribution behavior. In this sense, our approach is analogous to the social network analyses of factions in the extended party by Koger, Masket, and Noel (2009, 2010) and Heaney et al. (N.d.). It also represents a methodological innovation in the literature on identifying internal party factions, which has previously relied on reviews of historical materials (DiSalvo 2009), factor analyses of convention votes (Reiter 1980, 2004), and roll call voting data (Poole and Rosenthal 1997, 2007).

To determine the extent to which the party contribution networks within each legislative chamber are internally divided, we measure ideological factionalization using the network measure of modularity (Newman and Girvan 2004; Newman 2004, 2006). Modularity allows us to consider a particular partition, or allocation of members into distinct groups within the party network, and measure the extent to which contributions are made within those groups relative to what would be expected to occur randomly in a network with identical properties. We examine modularity calculated from partitions of each network based on ideological factions derived from summary statistics of roll call voting behavior (or *ideal point estimates*) and then assess whether the resulting partition exceeds the modularity expected by an allocation of members into identically-sized groups by random chance using the approach developed by Kirkland (N.d.). Finally, we compare the modularity of our ideologically defined factions with partitions identified by an automated community detection algorithm.

Formally, each of the party-chamber contribution networks can be represented as an adjacency matrix A_{ij} where the edge values represent the total value of contributions from member i to member j in the previous election cycle.[5] The modularity Q is thus defined as

$$Q = \frac{1}{4m} \sum_{ij} \left[A_{ij} - \frac{k_i k_j}{2m} \right] \delta(g_i, g_j) \tag{1}$$

where m represents the total value of contributions in the network (i.e., the sum of all edges in the network), k_i is the total value of contributions made by member i, g_i is the community to which member i belongs, and $\delta(g_i, g_j)$ equals 1 if members i and j are both in the same community and otherwise equals 0 (Newman and Girvan 2004; Newman 2004). As measured, modularity is a function of a particular partition G, which assigns each node to one of the communities identified in the network data.[6] Substantively, modularity in

[5] In practice, contributions are made in a dynamic process that unfolds over the course of an election cycle—members observe contributions being made by (and to) their colleagues and react accordingly. However, methods for addressing longitudinal variation in network structure are still being developed. We therefore analyze each network as a static cross-section at the Congress level based on giving in the previous electoral cycle.

[6] See Porter et al. (2007), Zhang et al. (2008), and Waugh et al. (N.d.) for other applications of modularity to

a weighted network such as this represents the total value of within-group contributions A_{ij} relative to the value of the contributions we would expect given the overall pattern of contributions in the network ($\frac{k_i k_j}{2m}$). It ranges from -1 to 1 where -1 represents contributions only being made across group lines and 1 represents contributions only being made within groups.

To determine whether contributions within legislative parties are internally polarized along ideological lines, it is necessary to identify ideological clusters or groups within the data. Following de Marchi, Ensley, and Tofias (N.d.), we group legislators using cluster analysis. In this case, we use k-means cluster analysis with an absolute/cityblock distance metric to three clusters in DW-NOMINATE ideal point estimates for legislators. We specify that the analysis identify three clusters, the minimum number required to accommodate the two dimensions of variation found by Poole and Rosenthal (1997, 2007).[7] Substantively, our use of three clusters allows for factional divides between moderates, extremists, and those legislators near the party median (the group Jessee and Malhotra 2010 call "middlepersons"). Alternatively, we might observe a moderate/extremist ideological divide along with a second dimension of variation (e.g., a regional cluster).

After estimating these ideological clusters, we propose to test the prediction that members of Congress give broadly across ideological lines due to selective incentives provided by parties. This theory corresponds to the null hypothesis that the modularity of the ideological clusters we identify does not exceed the levels we would expect by chance alone. In substantive terms, we expect that member-to-member contributions do not flow dispoportionately among factions of like-minded co-partisans. To precisely test this expectation, we use the permutation inference approach introduced by Kirkland (N.d.), which allows us to construct a reference distribution of modularity scores based on the partitions from the ideological clusters. By randomly reassigning cluster memberships among party members and recording the modularity of observed contribution patterns under these permutations,

Congressional politics.

[7] When they try to identify the maximum modularity partition of roll call voting for all members of Congress, Waugh et al. (N.d.) find three or more communities 32% of the time in the House and 61% of the time in the Senate.

we can identify the expected range of variation in modularity if the null were true. We can thus specify the null hypothesis formally.

> H_0: The modularity of contributions among ideological clusters Q_{IC} is no greater than we would expect for random permutations of the cluster assignments Q_R of the same network: $Q_{IC} = Q_R$.

If the modularity we observe does not exceed a specified critical value for the density of the reference distribution (e.g., 95%), we cannot reject the null hypothesis that modularity within ideological clusters is no higher than we would expect due to random chance. While failing to reject this null hypothesis cannot demonstrate that selective incentives provided by parties are the *reason* that contribution network modularity is relatively low among ideological clusters, it is consistent with the accounts provided in the literatures on partisan exchange theory (Cann 2008b) and partisan theories of legislative organization (Aldrich 1995; Cox and McCubbins 1994, 2005; Rohde 1991).

As a point of comparison, we use an automated community detection algorithm to identify an alternate set of communities within each party-chamber network. Our expectation is that an algorithmic approach will be able to recover partitions that generate levels of modularity that are at least as high as the ideological clusters. Moreover, we expect the partitions detected by the algorithm to identify meaningful groupings within the party contribution networks when they exist.

To date, community detection algorithms for directed, weighted networks are not well-developed.[8] We therefore use the walktrap community detection algorithm (Pons and Latapy 2006) in the `igraph` package for R (Csárdi and Nepusz 2006; R Development Core Team 2011), one of the few community detection algorithms implemented in publicly available software appropriate for the contribution network data because it incorporates edge weights. Substantively, it is desirable to account for contribution size since we expect that larger contributions represent closer ties between legislators. Unfortunately, walktrap

[8] Barrat et al. (2004) helped launch an increasingly sophisticated literature on complex weighted networks that holds promise for future studies.

does not account for directed ties, but the direction of ties is likely to be less consequential than contribution sizes in identifying party factions.

The walktrap algorithm starts with a network of n communities where n is the number of nodes in the network. It proceeds in $n - 1$ steps, repeatedly merging the two communities that are most closely interconnected in a series of random walks and updating its measure of network distance until it has collapsed the set of n communities into a single global community. The version of walktrap in `igraph` searches for the highest modularity score over the $n - 1$ steps given a specified random walk length. We search each network over random walks of length 1–200 to increase the chances that we find the maximum modularity partition (the highest modularity score across all instances of the search algorithm) and save the corresponding community assignment vector. Identifying the community structure that maximizes modularity is a difficult computational problem. Neither the walktrap algorithm nor any of the other search algorithms currently in use can be guaranteed to identify the global modularity maximum (Brandes et al. 2006; Good, de Montjoye, and Clauset 2010). Our purpose in using this algorithm is simply to provide a point of contrast with the ideological partition of the party contribution networks; we make no claim to have uncovered the partitions of global modularity maximums.

Data

Since we are interested in assessing the cohesion of the party-in-government and the resulting institutional influence of individuals within Congress, we define members and candidates who go on to serve in the subsequent session of Congress as the nodes in our network. We find that contributions are targeted toward other members of the party caucus in the chamber in which the legislator serves[9] and therefore focus on within-chamber giving in this paper, constructing separate networks by party for the House of Representatives and the Senate. This approach helps us to analyze factions within each party caucus

[9]Cross-chamber giving represents less than 10% of all member-to-member giving in this era and cross-party giving is exceptionally rare.

and to measure members' location in the network relative to their colleagues. In these networks, members of the House and Senate and candidates who will go on to serve in those chambers are nodes connected by edges representing contributions. These edges are directed (contributions flow from a giver to a receiver) and weighted (by the sum of all contributions from one member's campaign committee and/or leadership PAC to those of another member during an election cycle).[10]

To construct our dataset, we identified all cash and in-kind contributions between candidate committees and leadership PACs associated with members of Congress[11] for the 1986–2006 electoral cycles using the Federal Election Commission's "Any Transaction from One Committee to Another" data files.[12] We then extracted all contributions[13] from each cycle in which the givers and receivers were seated at the beginning of the subsequent session of Congress[14] (e.g., the 1986 electoral cycle was matched to the 100th Congress of 1987–88).

Our dataset has two primary advantages compared with previous studies of giving among members of Congress. First, previous studies focus almost exclusively on the House of Representatives (among recent studies, only Kanthak and Krause 2011 focuses on the Senate), but our data includes the Senate. Second, previous studies often include only contributions made by members via their leadership PACs, but we also include those made using campaign committee funds.

We also incorporate data on legislator characteristics. Members who served in House and Senate leadership positions were coded from annual editions of the *Congressional*

[10]We define "a contribution" as an edge representing *all* contributions from one member to another during a given election cycle. The value of gifts is measured in nominal dollars since contribution limits are fixed for much of this period and it's not clear that inflation adjustments are appropriate for comparing campaign contributions over time.

[11]Leadership PAC affiliations were coded from biennial editions of the *Almanac of Federal PACs*.

[12]`www.fec.gov/finance/disclosure/ftpdet.shtml`

[13]In our coding, we considered a contribution from a leadership PAC to be the same as a contribution from a member's campaign committee. For leadership PACs associated with several members, we coded the gifts as having come from (and/or having been received by) each member separately, but divided the total value of the contribution between the associated members. These made up fewer than 1% of all giver-receiver dyads in the data.

[14]We thus exclude members elected in special elections during the subsequent session of Congress.

Directory and the *Congressional Biographical Directory* (`http://bioguide.congress.gov`), while committee membership data were drawn from Nelson (1994) and Stewart and Woon (2011). We also measure members' policy preferences using ideal points estimated from Congressional roll call vote data—a common approach in political science. Specifically, we use Congress-level ideal point estimates from the DW-NOMINATE scaling procedure for binary choice data, which provide a measure of member preferences on a liberal-conservative dimension as well as a second dimension of cross-cutting issues such as civil rights (Poole and Rosenthal 2007).

Descriptions of the contribution networks

Since these data are novel, we first describe and analyze the aggregate properties of member-to-member giving and analyze how party contribution networks have changed over time before testing for ideological factionalization. These descriptive results provide context for our subsequent analyses and help validate the contribution data as a social network. Our analysis show that the networks have become more densely connected and include an increasing number of members who both give and receive contributions during the same election cycle. In addition, we show that leaders are typically the most central members.

The plots in Figure 1, which are disaggregated by party and chamber, display three measures of aggregate-level patterns in member-to-member giving during the 1986–2006 congressional election cycles among candidates who served in the subsequent Congress. Each shows a general trend toward increasing contribution activity from the early 1990s to 2004 and then a dramatic decline in GOP giving in 2006 (most likely the result of an especially unfavorable electoral environment).

[Figure 1 about here.]

Figures 1(a) and 1(b) plot the percentage of members who gave or received contributions from their colleagues by election cycle for the House and Senate, respectively (i.e., the proportion who appear as nodes in our network data). Net participation in the contribution

network increased substantially over the period we study, particularly among Republicans (excluding 2006). Figures 1(c) and 1(d) summarize the rapid growth in the number of arcs in the network (representing one or more contributions from one member to another in a given election cycle) using the unweighted density of the network for the House and Senate. This measure is defined as the number of arcs between network members divided by the total number of possible arcs.[15] Despite the seemingly large numbers of contributions, the density plot indicates that the congressional contribution network is relatively sparsely connected when compared to the cosponsorship networks studied by Fowler (2006a,b) and Zhang et al. (2008). Finally, Figures 1(e) and 1(f) presents the total value of all such contributions in the House and Senate per election cycle. Again, the total value of giving among members increased significantly, especially among Republicans, before dropping off during the 2006 cycle.

While summary statistics can provide important insights, it is often helpful to visualize networks. Figure 2 presents illustrative representations of Republican Senate contribution networks early and late in the period we study.

[Figure 2 about here.]

Figure 2(a) shows the GOP Senate network for the 101st Congress excluding the twenty isolates who neither gave nor received contributions from other members during the 1988 election cycle. Four senators—Thad Cochran (R-MS), Bob Dole (R-KS), Robert Kasten (R-WI), and Ted Stevens (R-AK)—dominate the network and are correspondingly central in the plot (vertex sizes are scaled by total within-caucus giving). Only three other senators gave more than one contribution. By contrast, Figure 2(b) shows a much more dense network in the 109th Congress—the expected result of the increased number of contributions and higher levels of participation shown in Figures 1(b) and 1(d). Every Republican senator gave or received at least one contribution to a colleague during the 2004 election cycle. The typical (median) Republican senator made nine contributions, with Mitch McConnell

[15] Formally, the density of a directed graph with L arcs and p nodes is $\frac{L}{p(p-1)}$. We include all members, including isolates, in p.

(R-KY) and Bill Frist (R-TN) giving more than thirty gifts apiece. In addition, many GOP senators received a large number of contributions from their colleagues, including nine who received more than 25 contributions each.

As Figure 2 suggests, members' contribution activity tends to be unevenly distributed toward either giving or receiving. Figure 3 illustrates the change in these patterns over time by plotting the indegree and outdegree values (i.e., the number of incoming and outgoing ties) for each node in the networks for the 101st Congress (1988 electoral cycle), 105th Congress (1996 electoral cycle), and 109th Congress (2004 electoral cycle). In these plots, we pool both parties and point out the differences between first year members and non-first year members in the House and between members who are up for re-election in a given election cycle and those who are not in the Senate.[16]

[Figure 3 about here.]

Not surprisingly, first-year members of the House are especially likely to be recipients of contributions, and senators are much more likely to give than receive contributions when they are not up for re-election. As in many social networks, the degree distribution is heavily skewed—the degree plots reveal that a few members are much more well-connected than their colleagues as either contributors or recipients.

However, we also observe a countervailing trend toward two-way participation in the contribution network. At first, only a tiny number of members participated as both givers and receivers for more than a few contributions in the same cycle. For instance, only two members of the 101st House and three members of the 101st Senate gave five or more contributions and also received five or more contributions. By the 109th Congress, however, approximately one-sixth of the House and Senate did so (71 House members and 16 Senators). This pattern is especially striking in the Senate among members who are up for re-election, who frequently gave *and* received contributions during the 2004 election cycle. In some cases, contributions were reciprocated within a dyad, particularly among Demo-

[16]Since members of the Senate serve six-year terms as opposed to the two-year terms served by members of the House of Representatives.

cratic senators (more than 20% of non-null dyads had reciprocal giving in the 106th and 109th Congresses). This pattern of giving is consistent with members adjusting to changed electoral circumstances by redistributing funds that are no longer needed for their own campaign efforts or soliciting contributions to help win an unexpectedly close race.[17]

Finally, to understand how legislators' positions in their caucus contribution network relate to other measures of institutional influence, we identify the most central members of Congress by chamber and party. In particular, legislators who hold leadership positions, serve as committee chairs, or have been assigned to prestigious committees are likely to hold central positions in their party network, while those who wish to ascend into those positions may engage in patterns of giving that move them toward the center of the network over time. We therefore assess the centrality of influential legislators within the network.

To measure centrality, we employ a new measure of closeness centrality for directed networks with edge weights that combines information about the number of contributions made by a legislator and the value of the contribution that the legislator makes (Opsahl, Agneessens, and Skvoretz 2010). Substantively, we expect that the act of contributing to a colleague is a meaningful expression of support but that the strength of such ties increases with the value of the contribution. Our measure of weighted closeness centrality attempts to incorporate the strength of such ties and thereby capture the extent to which members are closely connected to their colleagues through contributions. Substantively, we expect that members who score highly on this measure will be in the strongest position to exert influence within their caucus and to receive support in leadership races. In this sense, weighted closeness centrality is theoretically superior to the analogous version of weighted degree centrality (Opsahl, Agneessens, and Skvoretz 2010), which only accounts for the number and value of contributions rather than patterns of giving across the party.[18]

[17] Our unit of analysis in this study is the contribution network in Congress at time t formed by contributions during electoral cycle $t-1$. Future research should examine the dynamics of these contribution patterns more closely.

[18] The Opsahl, Agneessens, and Skvoretz (2010) version of weighted betweenness centrality is also less appropriate since it tends to identify members who are both givers and receivers in the network, which is less

Closeness centrality is typically calculated using minimum distance computations that treat the distance between nodes in a connected dyad as one unit. Opsahl, Agneessens, and Skvoretz (2010) instead define this distance as $\frac{1}{w^{\alpha}}$ where α is a tuning parameter and incorporate this definition into the standard definition of closeness (Freeman 1979). Setting $\alpha = 0$ returns the standard measure while $\alpha = 1$ returns the Newman 2001 and Brandes 2001 weighted measure. We set the tuning parameter α to 0.5, the midpoint between the unweighted and weighted measures, and calculate weighted closeness using the `tnet` library for R (Opsahl 2009).

The list of the most central members of Congress using this approach is presented in Table 1.

[Table 1 about here.]

The resulting set of most central members has strong face validity. For instance, the members with the highest closeness centrality in their party caucus include numerous party leaders such as Tom DeLay (R-TX) and Nancy Pelosi (D-CA), prominent members of Congress such as Ted Kennedy and Richard Lugar (R-IN), and presidential candidates such as Hillary Clinton (D-NY) and Bob Dole (R-KS). As expected, the lists are dominated by the top party leadership, who make up 64% of the most central members in the House and 45% in the Senate. In addition, when we compare the most central members in the party contribution networks to the most connected members of the bill cosponsorship networks (Fowler 2006a,b), it becomes clear that the two networks capture different aspects of the relationships between members of Congress. The only overlap between our list of the most central members in Table 1 and the Fowler (2006b) list of the best-connected legislators is Bob Dole in the 104th Senate. More generally, the correlation between our weighted closeness centrality measure and Fowler's connectedness scores is very low (0.12). These results suggest contribution network centrality is not simply another measure of legislative influence, but represents a different aspect of congressional politics.

relevant to our research question.

One question raised by these lists is to what extent centrality changes over time for institutionally ambitious members. To illustrate how legislators might use contributions to help fuel their rise through the party hierarchy, Figure 3 presents the centrality trajectories of four members who ascended into party leadership during the period covered by our data—David Bonior (Majority/Minority Whip; D-MI) and Tom DeLay (majority whip/majority leader) from the House and Tom Daschle (Majority/Minority Leader) and Bill Frist (Majority Leader; R-TN) from the Senate.

[Figure 4 about here.]

Each figure indicates the point at which the member was selected as a top party leader. In each case, these members became highly central to the party contribution network before winning a leadership contest.[19]

Modularity in party contribution networks

Having introduced and characterized the contribution network data, we are able to examine it for the incidence and extent of ideological factions. We first test for the presence of ideological factions by using a null hypothesis that modularity will *not* be higher in substatively defined ideological clusters than in comparable reference distributions of random partitions. We fail to reject the null for 82% of party/chamber/year networks (36 of 44), which is consistent with the claim that contemporary parties are generally successful at incentivizing contributions across ideological divisions. Next, we compare our ideologically defined cluster-based partitions to partitions of communities identified using an automated community detection algorithm. These groupings allow us to examine the character of those alliances which do appear to exist in the party contribution networks. In most cases, the community assignments produced by the algorithm, which have higher

[19] After being elected Majority Whip, Bonior made no contributions during the 1992 electoral cycle (and thus declined to a percentile rank of 0) in order to protect his seat against a repeat challenger in an unfavorable local electoral environment. Despite having a number of overdrafts at the House Bank, Bonior ended up winning with 53% of the vote in a year in which Bill Clinton received only 36% of the vote in his district.

modularity than our ideological clusters (suggesting a better fit to the data), indicate that member contribution behavior is not clearly divided along ideological lines.

Testing for ideological factionalization

Members of Congress are likely to want to support legislators with similar policy preferences, as Currinder (2003), Kanthak (2007), and Kanthak and Krause (2010) find, but does this tendency create a pattern of ideological factionalism in their contribution networks? If so, we would expect high levels of modularity among members with similar ideological views, reflecting a tendency for legislators to give more frequently to like-minded colleagues than we would expect due to chance alone. However, if parties successfully induce members to contribute broadly to their colleagues, then we would expect widespread giving across ideological lines and correspondingly low levels of ideological factionalism in the contribution network.

To answer these questions, we seek to identify internal divisions in each parties' roll call behavior using cluster analysis (specifically, k-means cluster analysis with an absolute-value distance metric). We cluster members according to ideal point estimates for the two dimensions of DW-NOMINATE for each party and chamber (i.e., House Democrats, Senate Democrats, House Republicans, and Senate Republicans) across every Congress from the 100th (1987-1988) to the 110th (2007-2008).[20] Figure 5 presents a sample plot of cluster assignments for House Democrats and Republicans in the 108th Congress (2003–2004).

[Figure 5 about here.]

We then calculate modularity for each party network using the ideological cluster assignments as a network partition. However, it is difficult to know the appropriate baseline for assessing the substantive or statistical significance of a modularity score, which is only

[20] We construct our ideological clusters using results from DW-NOMINATE because the ideal points it recovers were estimated using roll call votes by members of both parties, which preserves the predominantly partisan character of conflict featured in roll call voting in Congress.

a point estimate and may vary within some unknown range due to stochastic variation in human behavior, the structure of the network, and the number and size of the groups to which members of the networks are assigned. We therefore employ the Kirkland (N.d.) permutation test, which enables us to generate a reference distribution for each network and partition. Specifically, we randomly rearrange the cluster assignments of members of the party network while preserving the number and size of groups as well as holding constant the pattern of contributions made by each member. We then record the modularity scores of those permuted partitions. We repeat this procedure 1000 times, constructing a reference distribution which describes the modularity scores we might expect due to chance for a given network and partition. Finally, we compare the modularity scores of our ideological cluster partitions with their respective reference distributions, which lets us assess the extent to which contributions are more likely to be made within our estimated ideological clusters. If the modularity scores of the partitions based on ideological clusters do not deviate from the expected pattern of results due to chance (i.e., the nonparametric 95% and 99% confidence intervals for modularity generated using the permutation approach above), then we conclude that contributions within the party network are not well described by ideological factions.

The results of this procedure are presented in Figure 5, which includes both the modularity score from our ideological clusters as well as the 95% and 99% confidence intervals from the corresponding reference distribution.

[Figure 6 about here.]

Out of the 44 party/chamber/Congress combinations in our data, the modularity of 36 of 44 partition schemes based on the ideological clusters fail to exceed the 95% confidence interval of their reference distribution and 37 of 44 fail to exceed the 99% confidence interval. These results suggest that parties have generally been successful at inducing cooperation from members with ideologically disparate views. In particular, Senate Republicans never exhibited a statistically significant pattern of ideological factionalization in their contributions to each other. Similarly, Senate Democrats and House Republicans ex-

ceed the 95% confidence intervals for their party contribution networks only once each (in the congresses following the 1990 and 1992 electoral cycles, respectively). Of all the party networks, only House Democrats display a consistent tendency toward ideological giving. For the congresses following the six election cycles from 1990 to 2000, the modularity score of our ideological clusters exceeds the 99% confidence interval of the reference distribution.

Groupings identified using community detection

To examine community structure in these party contribution networks more closely, we employ an automated community detection algorithm. This approach, which provides a point of contrast to our cluster analysis of ideological factions, attempts to find the partition scheme which maximizes a network's modularity score by searching over all possible assignments of individuals to groups, which might identify factional structures based on different characteristics than ideology such as region, gender, race, religious affiliation, shared committee memberships, etc. After using the algorithm to identify the maximum modularity partition for each party network, we compare modularity levels between the algorithmic partitions and the partitions defined by our ideological clusters. Finally, we describe and interpret the composition of the largest internal partisan groupings.

In order to uncover the underlying community structure of each network, we search for the partition which exhibits the highest level of modularity using the walktrap algorithm (Pons and Latapy 2006) in `igraph` (Csárdi and Nepusz 2006). We vary the length of the random walks used by the algorithm from 1–200 and record the highest level of modularity discovered across all of its searches.

If the algorithm performs well, the modularity score for the partition it recovers for each network should be higher than the modularity score for the substantively-motivated partitions we constructed using cluster analysis. To the extent that the algorithm succeeds in finding a significantly better partition of the network, our results would suggest that the ideological cluster analysis has not identified a high-quality partition of the party contri-

bution network. In other words, the true community structure of the network would be based on a more complicated set of internal divisions or member characteristics.

Figure 7 plots the modularity of the best partition identified by the algorithm as well as the ideological clusters and associated reference distributions from Figure 6.

[Figure 7 about here.]

Across all of our networks, the walktrap algorithm almost always recovers a better partition than our ideological cluster assignments (the only exceptions are in the 1986 and 1988 in Democratic House network and in the 1992 Republican House network).[21]

Below, we interpret the largest communities detected using the search algorithm and find that these groupings typically include party leaders and other institutionally prominent members but rarely break down along clear ideological lines. In Figure , we focus on the size of the two largest groupings detected within the party caucuses using the algorithmic approach.

[Figure 8 about here.]

When combined, the two largest groups identified by the walktrap algorithm typically encompass a majority of non-isolate members in a party caucus (i.e., those that give or receive at least one contribution). The largest group in the Republican Senate network tends to be especially sizable, exceeding 50% of all active caucus members in six of eleven Congresses.[22] These groupings generally reflect patterns of contributions rather than differences in levels of giving—there are rarely statistically significant differences in the number of contributions made or received between the two largest groups (7% and 11%, respectively).

[21] On several other occasions, the walktrap algorithm fails to find a partition that exceeds the range of the 95% confidence interval of the reference distribution. This finding is consistent with previous research showing that it is difficult to find the global maximum for modularity and that its complex landscape will frequently hinder searches by heuristic algorithms (Brandes et al. 2006; Good, de Montjoye, and Clauset 2010).

[22] The two largest groups were equally large for House Republicans after the 1988 electoral cycle, Senate Democrats after the 1994 and 2004 cycles, and Senate Republicans after the 1990 cycle. In these cases, we arbitrarily designated one group as the largest and one as the second-largest.

These group also do not tend to differ in their estimated ideology. Across 44 party contribution networks, we can only reject the null of no difference between the two largest groups in their mean liberal-conservative ideology twelve times (27%).[23] Similarly, the mean difference between them was less than one standard deviation in first-dimension DW-NOMINATE space in all but four Congresses.[24] In addition, 50% of top party leaders (which we define as the Speaker of the House and the Majority/Minority Leaders and Whips in both the House and Senate) are in the largest group, which suggests that we frequently identify substantively important groupings of legislators in the party contribution networks.

To better understand the groupings identified by the algorithm, we present illustrative plots from the Democratic Senate network in the 103rd Congress (1992 electoral cycle) and 106th Congress (1998 electoral cycle) in Figure 6. White circles represent members of the largest group, gray diamonds represent the second-largest group, and black triangles represent members assigned to other, smaller groups.

[Figure 9 about here.]

Consider first Senate Democrats in the 103rd Congress, who are plotted in Figure 6(a). The grouping uncovered by the walktrap algorithm was a liberal-leaning group of senators clustered around Ted Kennedy (D-MA) and Tom Daschle (D-SD), while the second-largest group consisted of a group of more moderate Democrats centered on Bennett Johnson (D-LA), former Majority Leader Robert Byrd (D-WV), and James Exon (D-NE).[25]

These communities, though detected by an algorithm, correspond well to the two sides of the December 1994 Senate Minority Leader campaign between Daschle and Chris Dodd

[23] Findings are similar for differences on the second dimension (available upon request).

[24] The two largest groups of House Democrats in the 106th Congress of 1999-2000 were the most divided with a gap between first-dimension DW-NOMINATE means of approximately 1.6 standard deviations. The largest group was quite large (142 of 212 members) and contained nearly all of the prominent members of the Democratic caucus. The second-largest group was much smaller with only twelve members, including six from the South (which helps explain its more moderate ideological character). The most prominent member of the second-largest group was Ralph Hall (D-TX), who went on to switch parties and become a Republican in January 2004.

[25] A t-test rejects the null hypothesis that the groups' DW-NOMINATE mean first and second-dimension scores are equal ($p < .05$ and $p < .01$, respectively).

(R-CT). Daschle was originally set to face Jim Sasser (D-TN) in a race to replace Majority Leader George Mitchell (D-ME) that included competition to raise funds for allies (Jacoby 1994d). However, the contest was scrambled when Sasser lost his campaign for re-election and the GOP took control of the Senate. At the urging of Sasser supporters including Byrd, Dodd stepped in to challenge Daschle and narrowly lost a 24-23 vote in the party caucus. Though the vote was not made public, the lists of Daschle and Dodd supporters can be reconstructed from media reports (Jacoby 1994a,b,c, 1995; CongressDaily 1994a,b; Cohen 1994a,b; Hotline 1994; Wines 1994; O'Neill 1994).

During both the 1992 and 1994 electoral cycles, the walktrap algorithm uncovers a network partition with higher modularity than our ideological clusters. The detected communities help us understand the leadership battle that unfolded. Over that period, Daschle was a key figure in the largest detected grouping within the party's contribution network and Byrd was an important member of the second-largest faction (which included Dodd in 1992). Among those members of Daschle's factions in 1992 and 1994, nine of fifteen backed his leadership bid, while eight of fourteen members of Byrd's 1992 and 1994 factions supported Dodd.[26] In addition, four of the six Daschle faction members who did not support him are well-explained: Joe Lieberman (D-CT) supported Dodd, his colleague from Connecticut; Patty Murray (D-WA) backed Dodd after Byrd suggested that she might lose her seat on the Appropriations Committee if she supported Daschle (Jacoby 1994b); Kennedy was a close friend of Dodd's (Providence Journal-Bulletin 1994); and Barbara Boxer had previously backed Sasser in a bid to get a seat on the Finance Committee (Cohen 1994b). The linkage between contributions and support was especially strong among more senior senators: three of five in Daschle's faction who had already served two or more terms supported him, while the other senior senators went eight to one for Dodd. These correspondences suggest that the communities we detect in contribution networks represent meaningful alliances that might not otherwise be observable.

By contrast, the Senate Democratic contribution network from the 106th Congress por-

[26]One Byrd faction member who did not support Dodd was Reid, who was first considered challenging Daschle before eventually deciding to back him (Jacoby 1994b).

trayed in Figure (b) was less divided along ideological lines. The largest grouping centered on Harry Reid (D-NV), who narrowly won re-election in 1998 and was subsequently elected Minority Whip in 1999. Reid made contributions to 22 of his colleagues and received contributions from 11. The second-largest grouping centered on Kennedy and Daschle and included six of the nine members of the largest faction from the 103rd who were still in the Senate. However, because Reid distributed his largesse so widely despite being in the midst of a re-election campaign, the difference in mean DW-NOMINATE scores between the groups is not statistically significant.[27]

Conclusion

The flow of dollars between members of Congress has increased dramatically in recent years. By applying social network methods to these data for the first time, we provide new insights into member-to-member giving, the mechanisms of intra-congressional influence, and party factionalism. Contrary to previous research and expectations derived from majoritarian theories of Congress, we find that contributions are frequently made across ideological lines. When we examine the network modularity of ideological clusters of legislators, we find little evidence that contributions are disproportionately made within these groups. By contrast, groupings identified within the party contribution networks using an automated community detection algorithm frequently show much higher levels of modularity and do not reveal clear ideological divisions in contribution behavior within the parties.

These results are consistent with partisan theories of legislative organization, which emphasize how parties provide selective incentives to encourage cooperation to achieve shared electoral goals. The internal rewards for giving broadly across the party seem to be strong enough to avert the formation of ideological factions in the member contribution

[27] We cannot reject the null for either first-dimension scores ($p < .23$) or second-dimension scores ($p < .54$). The mean differences between groups are also substantively small (0.54 and 0.27 standard deviations, respectively).

network, which helps to demonstrate that parties can achieve their objectives in a relatively decentralized fashion.

We hope that our research will encourage further social networks research into the internal politics of Congress. For instance, the growing number of legislators both giving and receiving contributions suggests the need for further research to see if the flow of money through the network might be helping to broker legislative deals and exchanges of influence. In addition, we should consider legislators in a broader network context; they have multiple ties to other members across a variety of different settings. Contribution network ties could be combined with shared committee assignments (Porter et al. 2005, 2007), legislative cosponsorship (Fowler 2006a,b; Zhang et al. 2008; Cho and Fowler 2010), shared caucus memberships (Victor and Ringe 2009), and other ties to form a multiplex network. Contrasting the structure of these networks or analyzing them together could provide new insights into the increasing polarization of parties and the changing mechanisms of Congressional influence. In particular, the cosponsorship network might help help explain the formation of ties in the contribution network (and *vice versa*).

In subsequent work, we plan to use our measures of contribution network centrality to predict member success in moving upward within the party and committee leadership structure. We are particularly interested in assessing whether network-based centrality measures have more predictive power than simple counts of contributions made or total dollars given. In addition, exponential random graph models could be used to analyze the predictors of individual-level ties between members and to determine how those relationships have changed over time. Future scholarship might also consider the role of the party campaign committees, who are both recipients of "party dues" from members of Congress and donors to their campaigns. Finally, it would be worthwhile to more closely examine the structure of the extended party network, which includes interest groups, activists, donors, and consultants as well as members of Congress (see, e.g., Koger, Masket, and Noel 2009, 2010; Bernstein and Dominguez 2003; Bonica N.d.; Montgomery and Nyhan N.d.).

Social network analysis can help provide new insight into the often opaque dynamics of institutions such as political parties. In this paper, we have sought to apply those tools to measure ideological factionalization among members of Congress—an approach that we think holds significant promise for future research on parties and legislative organization.

References

Aldrich, John H. 1995. *Why Parties?* University of Chicago Press.

Aldrich, John H. 2011. *Why Parties? A second look*. University of Chicago Press.

Aldrich, John H., and David W. Rohde. 2000. "The Republican Revolution and the House Appropriations Committee." *Journal of Politics* 62 (January): 1–33.

Barrat, Alain, Marc Bartheélemy, Romualdo Pastor-Satorras, and Alessandro Vespignani. 2004. "The architecture of complex weighted networks." *Proceedings of the National Academy of Sciences* 101 (11): 3747–3752.

Bernstein, Jonathan, and Casey B.K. Dominguez. 2003. "Candidates and candidacies in the expanded party." *Political Science and Politics* 36 (02): 165–169.

Blasi, Vincent. 1994. "Free Speech and the Widening Gyre of Fund-Raising: Why Campaign Spending Limits May Not Violate the First Amendment after All." *Columbia Law Review* 94 (May): 1281–1325.

Bonica, Adam. N.d. "Ideology and Interests in the Political Marketplace." Unpublished manuscript.

Brandes, Ulrik. 2001. "A faster algorithm for betweenness centrality." *Journal of Mathematical Sociology* 25 (2): 163–177.

Brandes, Ulrik, Daniel Delling, Marco Gaertler, Robert Görke, Martin Hoefer, Zoran Nikoloski, and Dorothea Wagner. 2006. "Maximizing modularity is hard." *Arxiv preprint physics/0608255*.

Butts, Carter T. 2011. "sna: Tools for Social Network Analysis. Version 2.2.".

Cann, Damon M. 2008a. "Modeling Committee Chair Selection in the U.S. House of Representatives." *Political Analysis* 16 (3): 274–289.

Cann, Damon M. 2008b. *Sharing the Wealth: Member Contributions and the Exchange Theory of Party Influence in the U.S. House of Representatives*. State University of New York Press.

Cann, Damon M., and Andrew H. Sidman. 2011. "Exchange Theory, Political Parties, and the Allocation of Federal Distributive Benefits in the House of Representatives." *Journal of Politics* 73 (October): 1128-1141.

Cho, Wendy K. Tam, and James H. Fowler. 2010. "Legislative success in a small world: Social network analysis and the dynamics of congressional legislation." *Journal of Politics* 72 (1): 124–135.

Cohen, Lauren, and Christopher Malloy. 2011. "Friends in High Places: Peer Effects and Politics." Unpublished manuscript.

Cohen, Richard E. 1994a. "Sasser Favored in Leader's Race." *National Journal*, July 23, 1994.

Cohen, Richard E. 1994b. "Time for an Old-Fashioned Senate Leader." *National Journal*, July 30, 1994.

CongressDaily. 1994a. "Daschle Captures Minority Leader Post By One Vote." December 2, 1994.

CongressDaily. 1994b. "Hill Briefs." December 1, 1994.

Cox, Gary W., and Eric Magar. 1999. "How Much is Majority Status in the US Congress Worth?" *American Political Science Review* 93 (2): 299–309.

Cox, Gary W., and Mathew D. McCubbins. 1993. *Legislative Leviathan: Party Government in the House*. Berkeley: University of California Press.

Cox, Gary W., and Mathew D. McCubbins. 1994. "Bonding, structure, and the stability of political parties: Party government in the House." *Legislative Studies Quarterly* 19 (2): 215–231.

Cox, Gary W., and Mathew D. McCubbins. 2005. *Setting the Agenda: Responsible party government in the US House of Representatives*. Cambridge University Press.

Csárdi, Gábor, and Tamás Nepusz. 2006. "The igraph software package for complex network research." *InterJournal Complex Systems* 1695.

Currinder, Marian. 2008. *Money in the House: Campaign Funds and Congressional Party Politics*. Westview Press.

Currinder, Marian L. 2003. "Leadership PAC Contribution Strategies and House Member Ambitions." *Legislative Studies Quarterly* 28 (4): 551–577.

de Marchi, Scott, Michael Ensley, and Michael Tofias. N.d. "Partisan Influence in Congress and Institutional Change." Unpublished manuscript.

DiSalvo, Daniel. 2009. "Party Factions in Congress." *Congress & the Presidency* 36 (1): 27–57.

Engstrom, Eric J., and Georg Vanberg. 2010. "Assessing the Allocation of Pork: Evidence From Congressional Earmarks." *American Politics Research* 38 (6): 959–985.

Fenno, Richard F. 1973. *Congressmen in Committees*. Boston, MA: Little, Brown.

Fowler, James H. 2006a. "Connecting the Congress: A Study of Cosponsorship Networks." *Political Analysis* 14 (4): 456–487.

Fowler, James H. 2006b. "Legislative cosponsorship networks in the US House and Senate." *Social Networks* 28 (4): 454–465.

Freeman, Linton C. 1979. "Centrality in social networks: Conceptual clarification." *Social Networks* 1 (3): 215–239.

Good, Benjamin H., Yves-Alexandre de Montjoye, and Aaron Clauset. 2010. "Performance of modularity maximization in practical contexts." *Physical Review E* 81 (4): 046106.

Granat, Diane. 1984. "Parties' Schools for Politicians Grooming Troops for Election." *Congressional Quarterly Weekly Report* 42 (May): 1036. May 5, 1984.

Heaney, Michael, Seth Masket, Joanne Miller, and Dara Strolovich. N.d. "Healing the Rift? Social Networks and Reconciliation between Obama and Clinton Delegates in 2008." Unpublished manuscript.

Heberlig, Eric. 2003. "Congressional Parties, Fundraising, and Committee Ambition." *Political Research Quarterly* 56 (2): 151–161.

Heberlig, Eric, and Bruce Larson. 2005. "Redistributing Campaign Funds by US House Members: The Spiraling Costs of the Permanent Campaign." *Legislative Studies Quarterly* 30 (4): 597–624.

Heberlig, Eric, Marc Hetherington, and Bruce Larson. 2006. "The Price of Leadership: Campaign Money and the Polarization of Congressional Parties." *Journal of Politics* 68 (4): 992–1005.

Heberlig, Eric S., and Bruce A. Larson. 2010. "Congressional Parties and the Mobilization of Leadership PAC Contributions." *Party Politics* 16 (4): 451–475.

Herrnson, Paul S. 2009. "The Roles of Party Organizations, Party-Connected Committees, and Party Allies in Elections." *Journal of Politics* 71 (4): 1207–1224.

Hotline. 1994. "Senate: Daschle for Maj. Leader, but Dodd for Min. Leader." November 28, 1994.

Isenstadt, Alex, and James Hohmann. 2010. "Freshmen: Massa right about money." *Politico*, March 10, 2010. Downloaded July 5, 2011 from `http://www.politico.com/news/stories/0310/34244.html`.

Jacobson, Gary C. 1980. *Money in Congressional Elections*. New Haven: Yale University Press.

Jacoby, Mary. 1994a. "Armey on Clear Path For Majority Leader." *Roll Call*, November 10, 1994.

Jacoby, Mary. 1994b. "Daschle Beats Dodd For Minority Leader." *Roll Call*, December 5, 1994.

Jacoby, Mary. 1994c. "Sasser Holds Slim Lead Over Daschle." *Roll Call*, August 4, 1994.

Jacoby, Mary. 1994d. "Sasser's Drop in Polls Puts Focus on Daschle In Senate Leader Race." *Roll Call*, September 29, 1994.

Jacoby, Mary. 1995. "Democrats First to Finish Senate Committee Shuffle." *Roll Call*, January 9, 1995.

Jessee, Stephen, and Neil Malhotra. 2010. "Are Congressional Leaders Middlepersons or Extremists? Yes." *Legislative Studies Quarterly* 35 (3): 361–392.

Kanthak, Kristin A. 2007. "Crystal Elephants and Committee Chairs: Campaign Contributions and Leadership Races in the US House of Representatives." *American Politics Research* 35 (3): 389–406.

Kanthak, Kristin A., and George A. Krause. 2011. "Coordination dilemmas and the valuation of women in the US Senate: Reconsidering the critical mass problem." *Journal of Theoretical Politics* 23 (2): 188–214.

Kanthak, Kristin, and George A. Krause. 2010. "Valuing Diversity in Political Organizations: Gender and Token Minorities in the US House of Representatives." *American Journal of Political Science* 54 (4): 839-854.

King, Anthony. 1997. "The vulnerable American politician." *British Journal of Political Science* 27 (01): 1–22.

Kirkland, Justin H. N.d. "Hypothesis Testing with Network Partition Quality Statistics." Unpublished manuscript.

Koger, Gregory, Seth Masket, and Hans C. Noel. 2009. "Partisan webs: Information exchange and party networks." *British Journal of Political Science* 39 (3): 633–653.

Koger, Gregory, Seth Masket, and Hans C. Noel. 2010. "Cooperative party factions in American politics." *American Politics Research* 38 (1): 33–53.

Krehbiel, Keith. 1998. *Pivotal Politics: A Theory of U.S. Lawmaking*. Chicago: University of Chicago Press.

Montgomery, Jacob, and Brendan Nyhan. N.d. "The party edge: Consultant-candidate networks in American political parties." Unpublished manuscript.

Nelson, Garrison. 1994. "Committees in the U.S. Congress, 1947–1992." Electronic data, 99th to 102nd Senate.

Newman, Mark E.J. 2001. "The structure of scientific collaboration networks." *Proceedings of the National Academy of Sciences USA* 98 (2): 404–409.

Newman, Mark E.J. 2004. "Analysis of weighted networks." *Physical Review E* 70 (5): 056131.

Newman, Mark E.J. 2006. "Modularity and community structure in networks." *Proceedings of the National Academy of Sciences* 103 (23): 8577–8582.

Newman, Mark E.J., and Michelle Girvan. 2004. "Finding and evaluating community structure in networks." *Physical review E* 69 (2): 026113-1–026113-15.

O'Neill, James M. 1994. "New Senate leaders picked." *Providence Journal-Bulletin*, December 3, 1994.

Opsahl, Tore. 2009. *Structure and Evolution of Weighted Networks*. University of London (Queen Mary College), London, UK.
URL: *http://toreopsahl.com/publications/thesis/*

Opsahl, Tore, Filip Agneessens, and John Skvoretz. 2010. "Node centrality in weighted networks: Generalizing degree and shortest paths." *Social Networks* 32 (3): 245–251.

Ornstein, Norman J., Thomas E. Mann, and Michael J. Malbin. 2009. *Vital Statistics on Congress 2008*. Brookings Institution Press.

Pons, Pascal, and Matthieu Latapy. 2006. "Computing communities in large networks using random walks." *Journal of Graph Algorithms and Applications (JGAA)* 10 (2): 191–218.

Poole, Keith T., and Howard Rosenthal. 1997. *Congress: A political-economic history of roll call voting*. Oxford University Press.

Poole, Keith T., and Howard Rosenthal. 2007. *Ideology and Congress*. Transaction Publishers.

Porter, Mason A., Peter J. Mucha, M.E.J. Newman, and A.J. Friend. 2007. "Community structure in the United States House of Representatives." *Physica A: Statistical Mechanics and its Applications* 386 (1): 414–438.

Porter, Mason A., Peter J. Mucha, M.E.J. Newman, and Casey M. Warmbrand. 2005. "A network analysis of committees in the US House of Representatives." *Proceedings of the National Academy of Sciences USA* 102 (20): 7057–7062.

Providence Journal-Bulletin. 1994. "Sen. Dodd may seek leader post." November 10, 1994.

R Development Core Team. 2011. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. ISBN 3-900051-07-0.
URL: *http://www.R-project.org/*

Reiter, Howard L. 1980. "Party Factionalism." *American Politics Research* 8 (3): 303–318.

Reiter, Howard L. 2004. "Factional persistence within parties in the United States." *Party Politics* 10 (3): 251–271.

Rohde, David W. 1991. *Parties and Leaders in the Postreform House*. Chicago: University of Chicago Press.

Stewart, Charles, and Jonathan Woon. 2011. "Congressional Committee Assignments, 103rd to 112th Congresses, 1993–2011." Electronic data for House and Senate.

Victor, Jennifer Nicoll, and Nils Ringe. 2009. "The social utility of informal institutions: Caucuses as networks in the 110th US House of Representatives." *American Politics Research* 37 (5): 742–66.

Waugh, Andrew Scott, Liuyi Pei, James H. Fowler, Peter J. Mucha, and Mason A. Porter. N.d. "Party Polarization in Congress: A Network Science Approach." Unpublished manuscript.

Wilcox, Clyde. 1989. "Share the Wealth: Contributions by Congressional Incumbents to the Campaigns of Other Candidates." *American Politics Quarterly* 17 (4): 386–408.

Wilcox, Clyde, and Marc Genest. 1991. "Member PACs as Strategic Actors." *Polity* 23 (3): 461-470.

Wines, Michael. 1994. "A Forceful Conservative as G.O.P. Whip, a Clinton Ally to Lead Democrats – Thomas Andrew Daschle." *New York Times*, December 3, 1994.

Zhang, Yan, A.J. Friend, Amanda L. Traud, Mason A. Porter, James H. Fowler, and Peter J. Mucha. 2008. "Community Structure in Congressional Cosponsorship Networks." *Physica A: Statistical Mechanics and its Applications* 387 (7): 1705–1712.

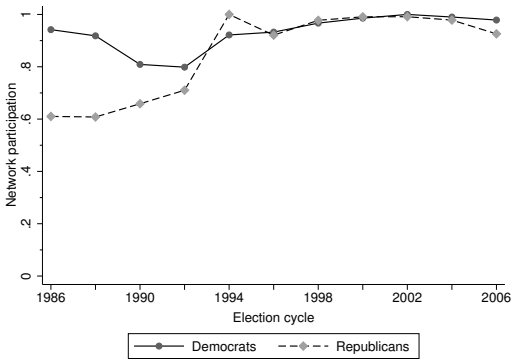
Table 1: The most central members of Congressional contribution networks

	House		Senate	
Year	Democrat	GOP	Democrat	GOP
1986	Coelho (CA-15)	Kemp (NY-31)	Byrd (WV)	Dole (KS)
1988	Coelho (CA-15)	Hunter (CA-45)	Inouye (HI)	Dole (KS)
1990	Gephardt (MO-3)	Michel (IL-18)	Kennedy (MA)	Dole (KS)
1992	Foley (WA-5)	Michel (IL-18)	Kennedy (MA)	Dole (KS)
1994	Rose (NC-7)	McCollum (FL-8)	Exon (NE)	Dole (KS)
1996	Matsui (CA-5)	Armey (TX-26)	Kennedy (MA)	Mack (FL)
1998	Gephardt (MO-3)	Armey (TX-26)	Kennedy (MA)	Lott (MS)
2000	Pelosi (CA-8)	DeLay (TX-22)	Daschle (SD)	Hagel (NE)
2002	Pelosi (CA-8)	DeLay (TX-22)	Reid (NV)	Shelby (AL)
2004	Hoyer (MD-5)	DeLay (TX-22)	Clinton (NY)	Frist (TN)
2006	Murtha (PA-12)	Doolittle (CA-4)	Levin (MI)	Lugar (IN)

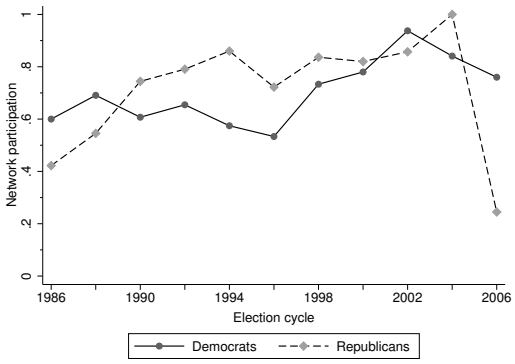
Members with the highest weighted closeness centrality by party, chamber, and Congress (Opsahl, Agneessens, and Skvoretz 2010)

Figure 1: Levels of giving in the Congressional contribution network

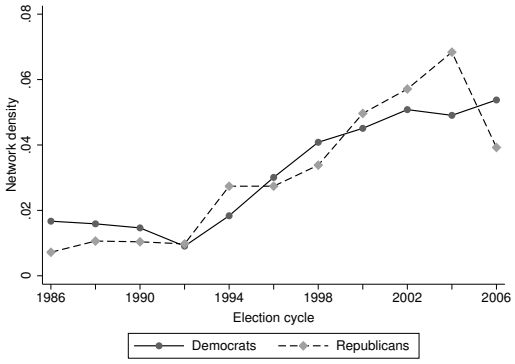
(a) Percent in network: House



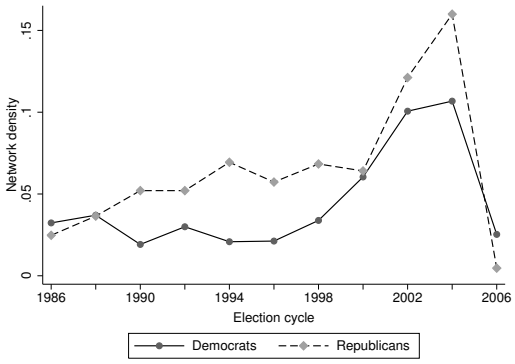
(b) Percent in network: Senate



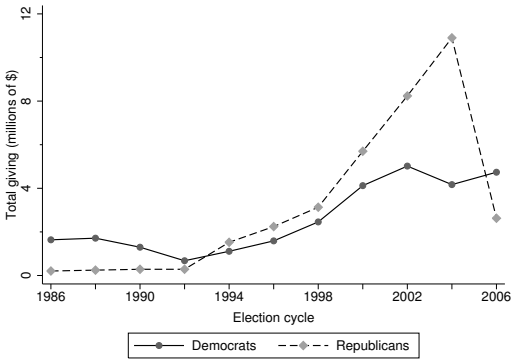
(c) Network density: House



(d) Network density: Senate



(e) Total giving: House



(f) Total giving: Senate

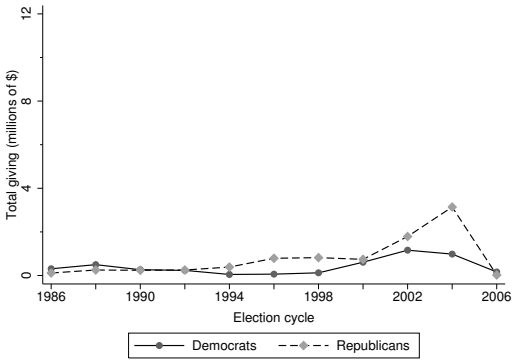
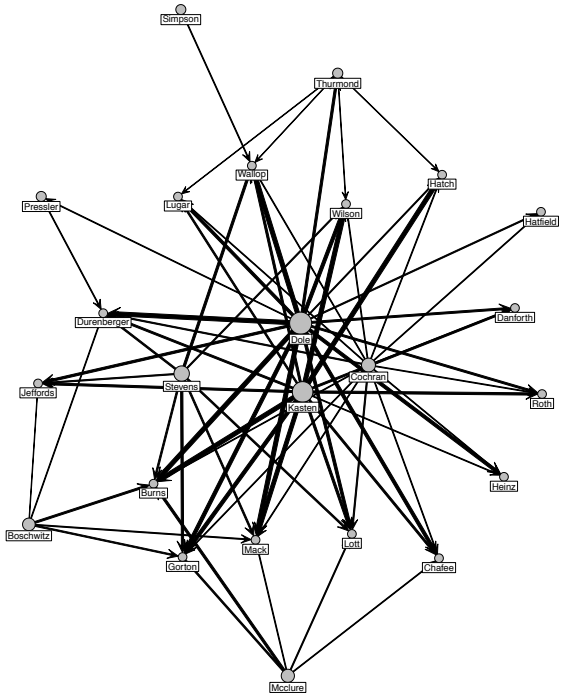
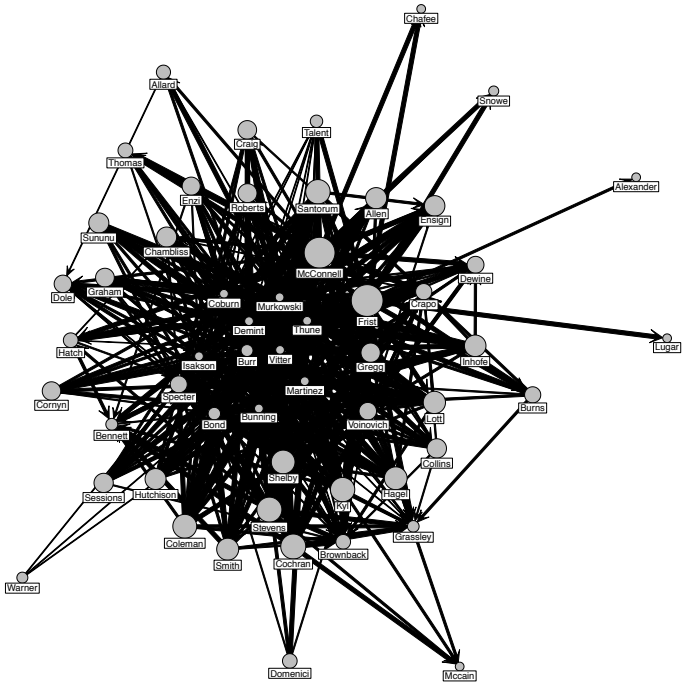


Figure 2: Change in the Republican Senate contribution network

(a) 101st Congress (1988 electoral cycle)

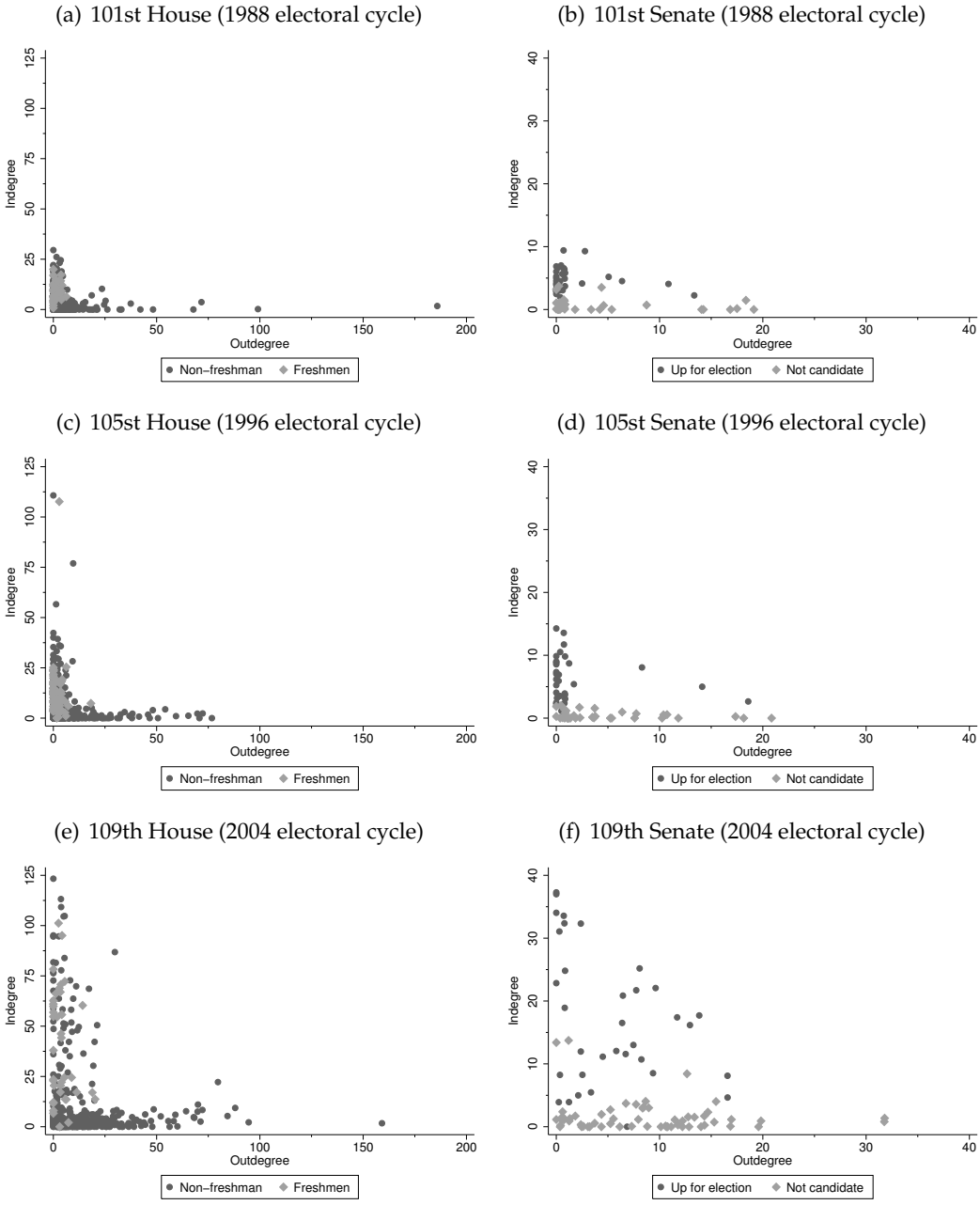


(b) 109th Congress (2004 electoral cycle)



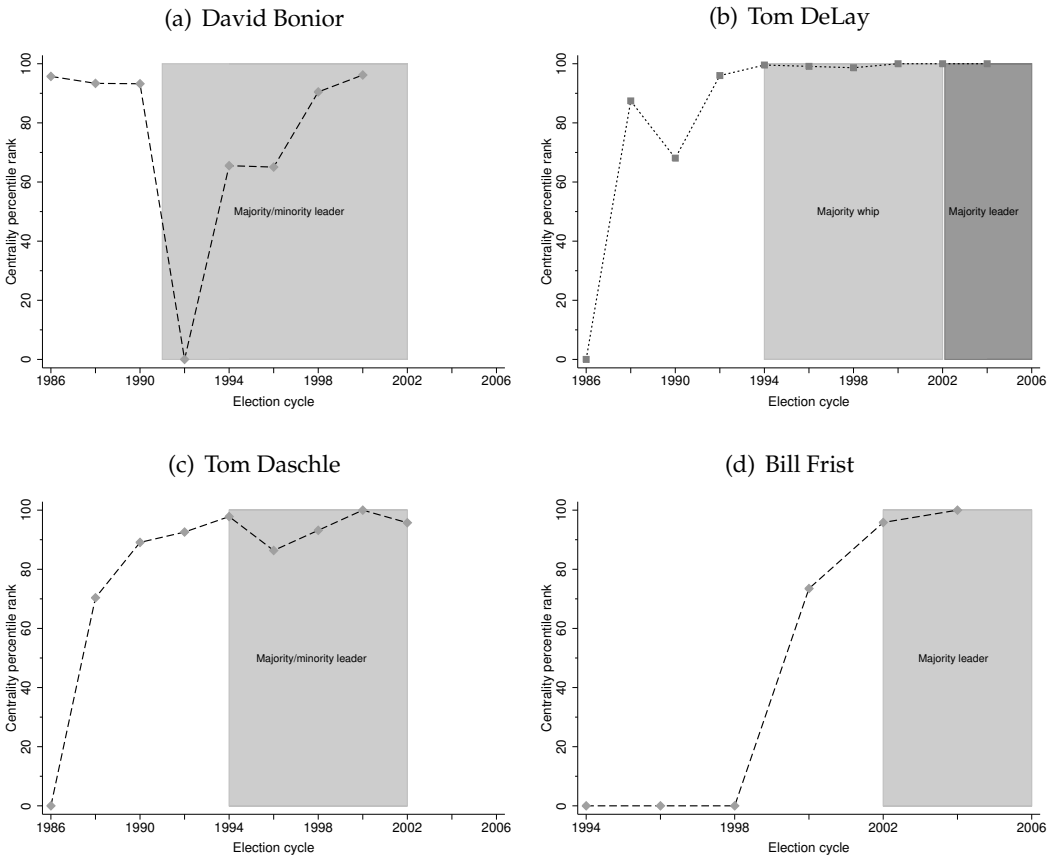
Network plots made using the `sna` library (Butts 2011) and laid out using the Fruchterman-Reingold algorithm. Vertex sizes are scaled by the dollar amount of total giving to other members in the network and arc widths and arrowhead sizes are scaled by the value of the contribution. Isolates are not included.

Figure 3: In- and out-degree distributions over time



To increase clarity, the points in these scatterplots have been jittered up to 5% of the height and width of the graph in Stata due to ties in indegree and outdegree values. This procedure makes it possible to see how many members have the same indegree and outdegree values (they would otherwise be plotted on top of each other).

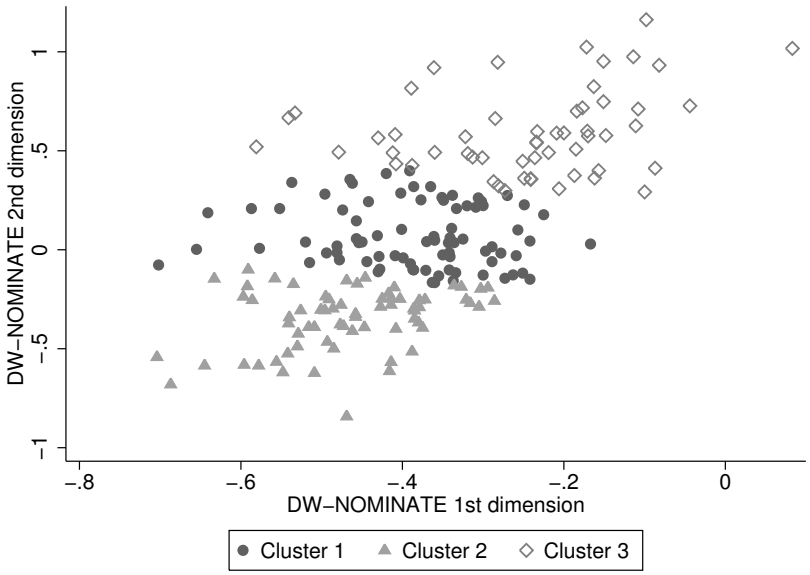
Figure 4: Prominent career trajectories within the partisan networks



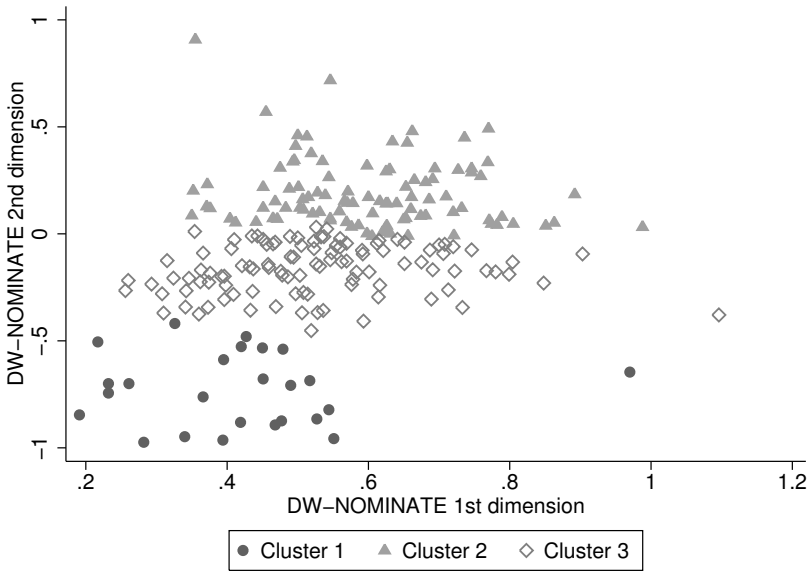
These graphs plot the percentile rank for each member within their caucus using the weighted closeness centrality measure of Opsahl, Agneessens, and Skvoretz (2010).

Figure 5: Ideological cluster assignments (108th Congress, 2003–2004)

(a) House Democrats



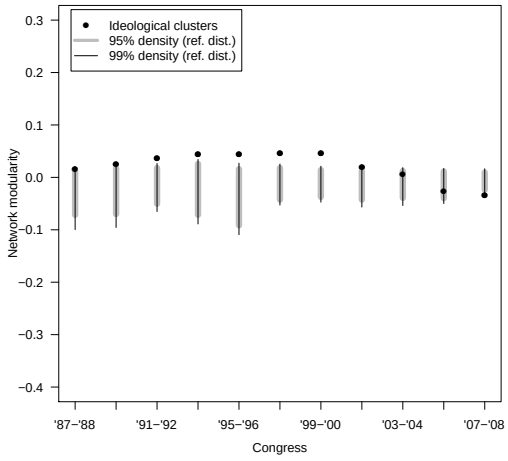
(b) House Republicans



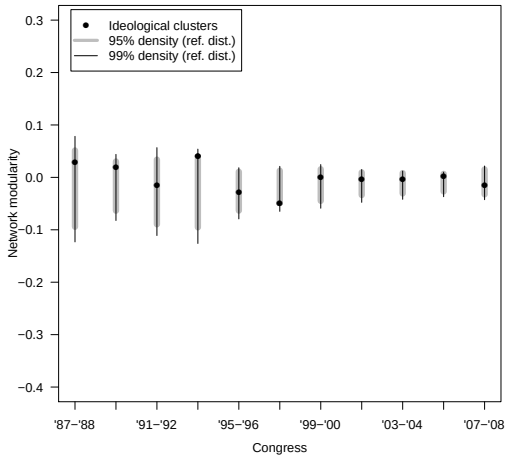
Legislators were clustered according to their ideal point estimates for the two dimensions of DW-NOMINATE (Poole and Rosenthal 2007) using k-means cluster analysis with an absolute-value distance metric.

Figure 6: Network modularity in ideological clusters by party and chamber

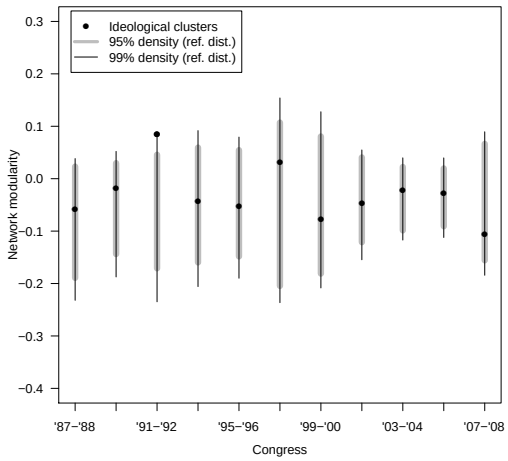
(a) House Democrats



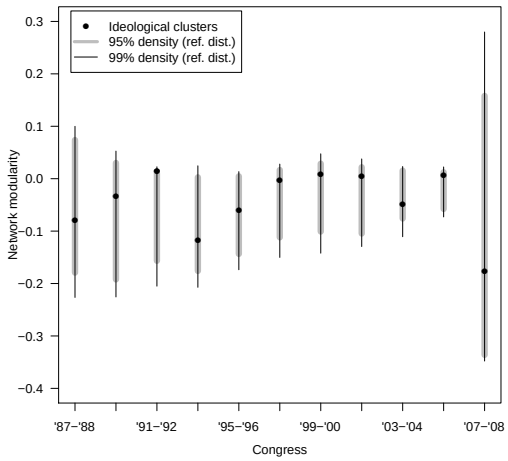
(b) House Republicans



(c) Senate Democrats



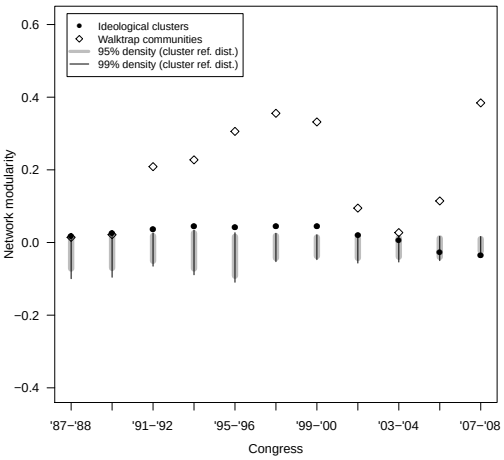
(d) Senate Republicans



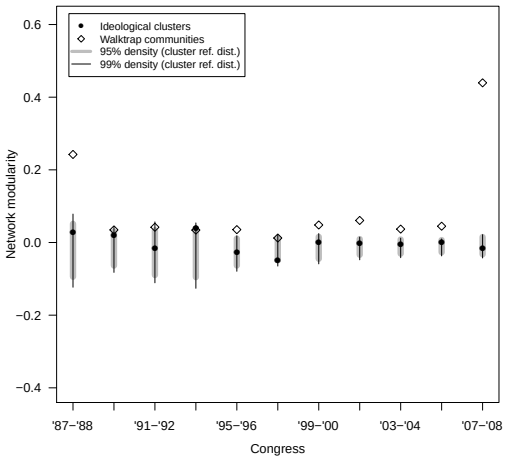
These graphs plot the network modularity by party and chamber for ideological clusters estimated from DW-NOMINATE ideal point estimates (Poole and Rosenthal 2007) along with nonparametric confidence intervals constructed using the permutation approach in Kirkland (N.d.).

Figure 7: Network modularity: Ideological clusters and automated detection

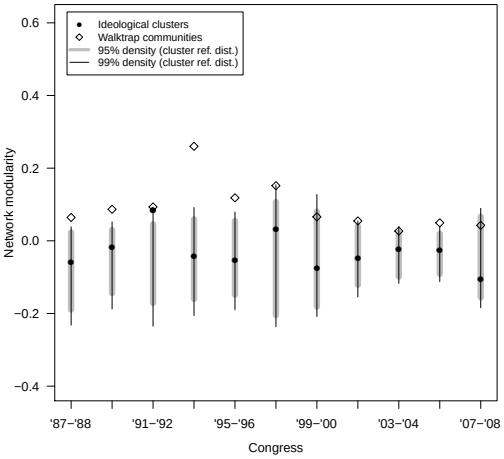
(a) House Democrats



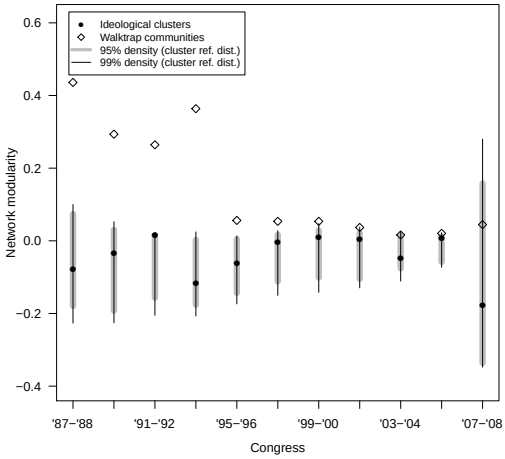
(b) House Republicans



(c) Senate Democrats

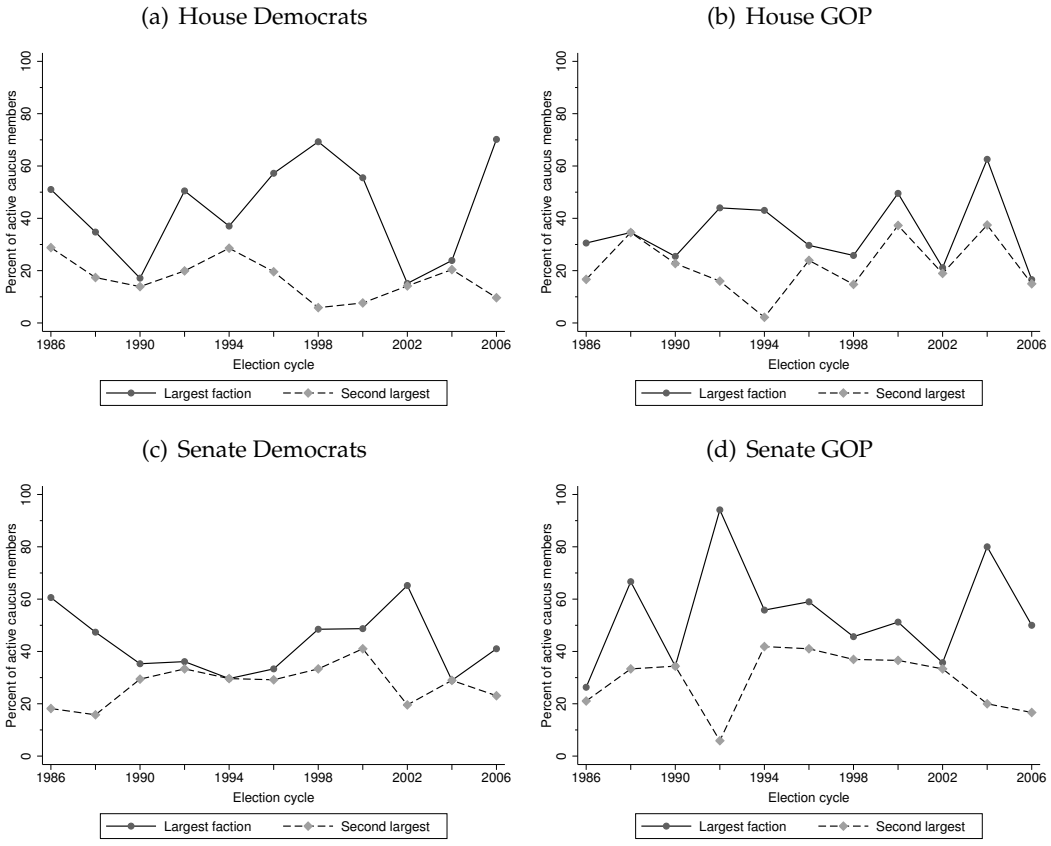


(d) Senate Republicans



These graphs plot the highest level of modularity found using the walktrap algorithm (Pons and Latapy 2006) in `igraph` (Csárdi and Nepusz 2006) with random walks of length 1–200. We also plot the network modularity by party and chamber for ideological clusters estimated from DW-NOMINATE ideal point estimates (Poole and Rosenthal 2007) along with nonparametric confidence intervals for those point estimates constructed using the permutation approach in Kirkland (N.d.).

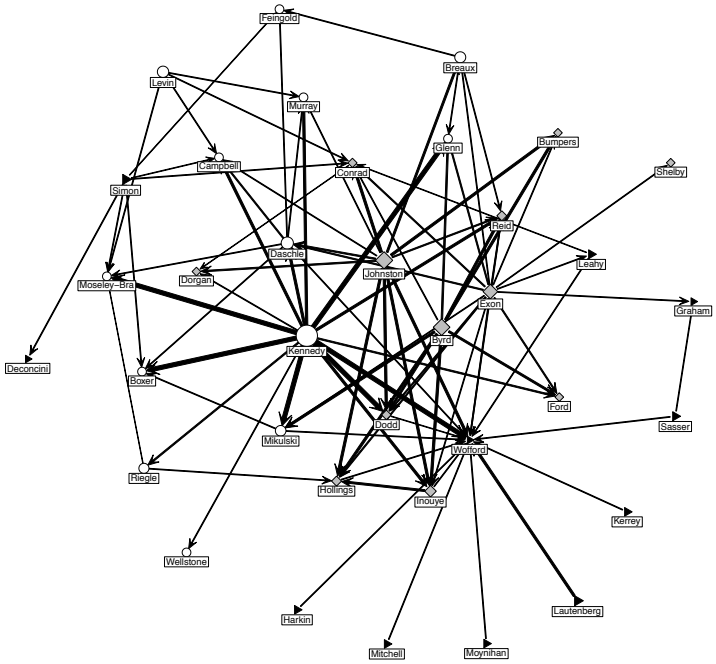
Figure 8: Membership size of largest party factions



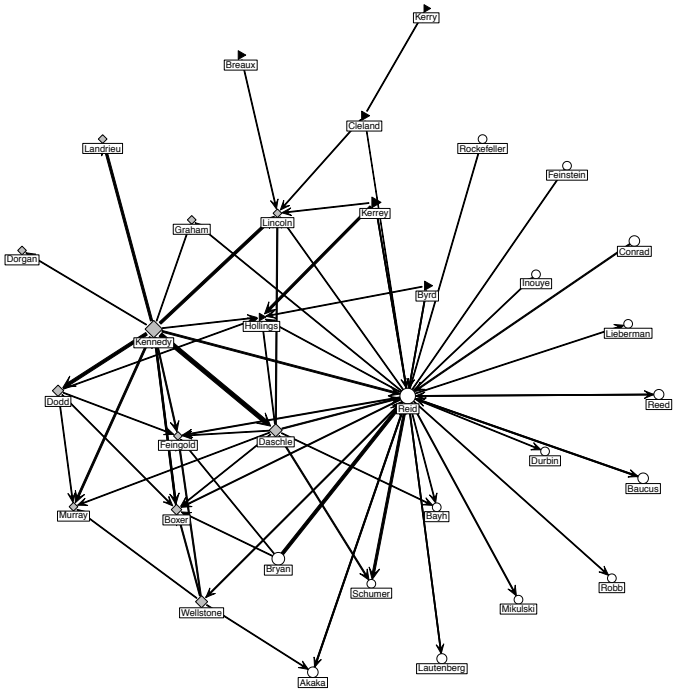
The plotted values represent the percentage of non-isolate nodes in the two largest groups in each contribution network. Group memberships were derived from the community assignment vectors that generated the highest levels of modularity using the walktrap algorithm (Pons and Latapy 2006) in `igraph` (Csárdi and Nepusz 2006) with random walks of length 1–200.

Figure 9: Communities in the Democratic Senate contribution network

(a) 103rd Congress (1992 electoral cycle)



(b) 106th Congress (1998 electoral cycle)



White circles represent members of the largest party group, gray diamonds represent the second-largest group, and black triangles represent members assigned to other, smaller groups. Group memberships were derived from the community assignment vectors that generated the highest levels of modularity using the walktrap algorithm (Pons and Latapy 2006) in `igraph` (Csárdi and Nepusz 2006) with random walks of length 1–200. Network plots made using the `sna` library (Butts 2011) and laid out using the Fruchterman-Reingold algorithm. Vertex sizes are scaled by total giving to other network members (in dollars) and arc widths and arrowhead sizes are scaled by the value of the contribution. Isolates are not included.