

LEGISLATIVE SUCCESS IN A SMALL WORLD
SOCIAL NETWORK ANALYSIS AND THE DYNAMICS OF CONGRESSIONAL LEGISLATION

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Abstract

We examine the social network structure of Congress from 1973–2004. We treat two Members of Congress as directly linked if they have cosponsored at least one bill together. We then construct explicit networks for each year using data from all forms of legislation, including resolutions, public and private bills, and amendments. We show that Congress exemplifies the characteristics of a “small world” network and that the varying small world properties during this time period are strongly related to the number of important bills passed.

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1 Small World

In a seminal article about “small world” networks, Watts and Strogatz (1998) identified a variety of different kinds of networks that exhibit two common properties. First, they had a small average shortest path length so that most nodes in the network could be reached by any other node in a small number of steps. Second, they had a large amount of clustering so that the nodes connected to a given node are also likely to be connected to one another, forming dense overlapping triads throughout the network. A small world network is said to exist if the mean shortest path length is significantly smaller than the mean-shortest path length in a random graph of the same size, and the average level of clustering is significantly higher than it is in a corresponding random graph. Further research has shown that the small world phenomenon is manifested in many networks, including telephone call graphs, networks composed of proteins, food chains, and metabolite processing networks, to name a few (Watts, 1999; Albert and Barabasi, 2002).

Although there has been a rush to identify small world networks and their theoretical properties, there has been comparatively less work focused on the consequences or impact of small worlds. That is, how does the unique structure of a small world system, where actors are densely connected with few intermediaries, affect the dynamics of the system? Some of the work that has been done indicates that the characteristics of small worlds do indeed have an impact on the dynamics of these social systems. For instance, Fowler (2005) studied the dynamics of voter turnout decisions in small world networks and found that one person’s vote decision caused cascading behavior, yielding an average of three additional votes for one’s preferred candidate. Uzzi and Spiro (2005) examined the small world of Broadway musicals from 1945 to 1989 and found that the varying small world properties affected the creativity of Broadway musicals. Newman (2001) studied the scientific collaboration of scholars and concluded that the small world structure may have an impact on the speed of information and idea dissemination in academic work. Kogut and Walker (2001) show that firms with higher centrality and lower average path lengths are more

likely to be involved in takeovers and restructurings. Fleming and Marx (2006) demonstrated that patent inventors comprise a small world and that the structure of this small world affects how innovation is realized. And, Davis, Yoo and Baker (2003) found the small world structure to affect the dynamics among directors of corporations with “linchpins” holding the network together. The common thread among these studies is their demonstration of how the small world structure of networks plays an important role in the way they perform.

In this paper, we seek to extend this line of research into studies of the U.S. Congress, which appears to be clearly a small world. In particular, we examine how the social structure of Congress affects the dynamics of legislation. Thus far, virtually all studies of Congress focus heavily on characteristics of a particular Congress (e.g. the partisan divide, the party of the President) or external forces (e.g. economic situation), with nary a nod to how the social relationships between Members of Congress might be tied to legislative output and productivity. We begin by describing our congressional network and how we measure social connectedness between Members of Congress. We then formally define the characteristics of a small work network and describe how and the extent to which Congress exhibits small world properties. We then seek to explore how the variation in small world network characteristics from year to year affect the output of important legislation. We proceed with an analysis anchored in a seminal study in political science on legislative productivity. We conclude by discussing the impact of social network structure on the performance of Congress.

2 Dynamics of Congressional Legislation

Congress is an example of a social network (Fowler, 2006; Porter et al., 2005; Zhang et al., 2008), a social entity where the actors are interdependent and have relationships with others in the network. Of course, describing a social network requires a way to define relationships between the actors, and there are various ways in which one might specify how the members of the network

are connected to one another. Here, we define two members of Congress as linked if they have cosponsored the same bill. Surely, relationships among Members of Congress are complex, often the result of institutional designs such as the organization of congressional committees (Porter et al., 2005) or partisan structuring (Zhang et al., 2008), and cosponsorship is only one means of identifying which Members of Congress work together on legislation. Ideally, we would be privy to all communications, official and unofficial, written and oral, on and off the record, casual and formal, regarding each piece of legislation. Since this information is not available, we use a data-driven decision rule to employ cosponsorship as the defining relation between Members of Congress on a particular piece of legislation.

One might discount the effect of the cosponsorship network on the performance of Congress since the cost of cosponsorship is low (Kessler and Krehbiel, 1996). Despite the ease of cosponsorship for legislators, a number of scholars have provided evidence that cosponsorship contains valuable information about how well members of Congress work together. Campbell (1982) notes that legislators expend considerable effort recruiting cosponsors with personal contacts and “Dear Colleague” letters. Representative Joseph Kennedy, wrote in a Dear Colleague letter dated January 12, 1998,

...It is time we dissociate ourselves with the School of the Americas once and for all.

Join 129 of your colleagues in closing down the School by becoming a cosponsor of H.R. 611. To cosponsor, call Robert Gerber at 5-5111.

Moreover, legislators frequently refer to these cosponsorships in floor debate, public discussion, letters to constituents, and campaigns. In a hearing of the House Ways and Means Committee on January 28, 1998, Representative Wally Herger paraded both the number of cosponsors as well as the bipartisanship represented by the cosponsors for H.R. 2593, the Marriage Penalty Relief Act. Further, in Representative William Colmer’s words in support of the bill to formalize cosponsorships in the House in 1967,

The cosponsorship of a bill adds prestige and strength to the proposed legislation. For there is strength in unity. The proposal is given status by numbers (Congressional Record 1967: 10710).

Thus, legislators themselves behave in a way that indicates they find some value in cosponsorship, suggesting that it is not merely “cheap talk.” Cosponsorship activity has also been used by scholars to identify leadership hierarchies in the UN (Stokman, 1977), as a measure of coalition-building proclivities (Wawro, 2001), and as a predictor of which sponsors are most likely to achieve success in floor votes (Fowler, 2006). Koger (2003) shows that legislators increasingly cosponsor with members of the other party when they are under electoral pressure. In short, even if scholars disagree on the exact informational content of bill cosponsorship, scholars and politicians alike appear to agree that cosponsorship is a social act that is meaningful and significant.

Although there are different theories for why cosponsorship occurs, each of these theories recognizes that cosponsorship embodies a social component by bringing together members of Congress via shared interests or attributes. Electoral connection theories (Mayhew, 1974) posit that legislators who cosponsor are ideologically similar or are perhaps linked by electoral security (e.g. marginal versus safe districts). Theories of intralegislative signaling suggest cosponsorship is a social act meant to influence other legislators (Kessler and Krehbiel, 1996). Scholars have also used cosponsorship to document links between legislators defined by expertise and budgetary preferences (Gilligan and Krehbiel, 1997; Krehbiel, 1995). Whatever the linking mechanism, a common thread in this literature is that groups of cosponsors share significant social experiences and attributes.

Social relationships between legislators are difficult to observe, and while cosponsorship is not a perfect measure of this phenomenon, it is quantifiable and does appear to tap the social fabric of Congress. This is propitious for the study of Congress, since the gap lies not in the theoretical concept that intralegislative social relationships would influence the conduct of Congress, but in the

empirical demonstration of this theory. Indeed, although congressional scholars, such as Kingdon (1973), long ago generated descriptions of how members of Congress relate to one another and how these relationships affect their voting decisions, these theories have scarcely been quantified and tested on the large congressional data sets we have now compiled.¹

Thus, if cosponsorship indicates either a working relationship or the degree to which legislators have a history of working together, then we expect greater interconnectivity in cosponsorship to signal an increase in cooperation which may lead to increased productivity by the Congress as a whole. It is clear that it is difficult for any single member of Congress to construct landmark legislation in isolation. Both crafting legislation and passing legislation are aided by the help of others. A Congress where the members did not interact at all would plainly behave differently and have a different impact than one in which collaboration and cosponsorship were commonplace. Indeed, the act of cosponsorship aids legislative functions in a variety of ways. Cosponsors help craft legislation in the early stages, and innovation may be enhanced through joint collaborations. Cosponsors are instrumental as well in later stages when the sponsors of a bill need to gather support. Some work actively while others help simply by the signal of support they provide as a cosponsor (Mayhew, 1974; Campbell, 1982; Kessler and Krehbiel, 1996). We therefore expect that the structure of cosponsorships would be instrumental to the successes claimed by Congresses.

The literature on Congressional productivity has focused on characteristics of Congress or external factors such as “mood” or the budgetary situation, but it has yet to consider the effect of social dynamics within the Congress. The best known model of productivity is Mayhew (2005), and it would be difficult to overstate its influence. Mayhew (2005) has been cited well over 1000 times and has additionally inspired a literature aimed at understanding legislative productivity (see, e.g. Howell et al., 2000; Binder, 2003; Clinton and Lapinski, 2006) At the same time, none of this

¹One exception is a recent study of the social interactions between members of different committees where Baughman (2006) showed that in spite of increasing overlap in jurisdictions between committees, cooperation has actually improved and is strongest when members from each committee share similar interests. He also demonstrated that a history of prior working relationships helps to promote cooperation because it helps to define expectations about both interests and jurisdictions.

literature has explicitly considered variation in the aggregate patterns of social relationships and how these might affect the policies produced by Congress.

We intend to demonstrate that the Congressional social network is an instance of a special class of “small world” networks, and that this network creates a social organization with unique dynamics that influences creativity and productivity and thereby affects the performance of Congress. We will show that the more the network exhibits the properties of a small world network, the more connected the actors are to each other and the more they are able to produce landmark legislation.

2.1 Small Worlds and Social Networks

The small world as folklore has recently been formalized as a network structure defined by a graph with nodes and links that exhibit both high levels of local clustering and a short average path length between nodes (Watts and Strogatz, 1998; Watts, 1999). The small world measure can be operationalized through the “small world quotient,” Q , which is a function of two specific characteristics of the network, the transitivity index (τ) and the average path length between any two nodes (PL). The transitivity index measures the average fraction of a legislator’s cosponsors who are also cosponsors with one another. A relation is transitive if whenever i and j are friends and j and k are friends, then i and k are friends. So there is a fully linked triad of nodes. As the proportion of transitive relations increases in a network, the network is regarded as being more “balanced” and having more stability than one in which a link of the triad is missing.

[Figures 1 about here.]

Figure 1 gives an example of how the transitivity index is computed for one node in a network. In this figure, the clustering coefficient is given for the solid black node. Lines indicate connections between the nodes, and the open circles are neighboring nodes of the solid black node. The darker lines show links among the neighboring open circle nodes. In the leftmost network, the transitivity index (τ) is 1 because all of the solid black node’s neighbors are linked with one another. In the

second network, τ is $2/3$ because two thirds of the possible links exist while one does not. In the next network, only 1 of the possible 3 links exist, and so the τ is $1/3$. Lastly, none of the neighbors are connected in the fourth network, so the τ for the solid black node in that network is 0.

Formally, define a graph G as a set of n vertices or nodes, $V = v_1, v_2, \dots, v_n$ and a set of edges or links, $E = e_{ij}$, between those vertices where e_{ij} denotes a link between vertex i and vertex j . Each vertex has a neighborhood, N , which is defined as its directly connected neighbors,

$$N_i = \{v_j\} : e_{ij} \in E. \quad (1)$$

Let $k_i = |N_i|$ be the degree of vertex i . The transitivity index for vertex i , τ_i , is the proportion of links between the vertices within its neighborhood divided by the number of possible links in the neighborhood. For an undirected graph, the transitivity index is

$$\tau_i = \frac{2|\{e_{jk}\}|}{k_i(k_i - 1)} \quad v_j, v_k \in N_i, e_{ij} \in E. \quad (2)$$

For the entire graph, the transitivity index is the average of the individual transitivity indices,

$$\bar{\tau} = \frac{1}{n} \sum_{i=1}^n \tau_i \quad (3)$$

In our network, each member of Congress is a node. Members of Congress who cosponsor at least one bill together have a direct link between them.

To obtain a measure of the degree of small worldness in a network, Watts and Strogatz (1998) proposed comparing the actual network's path length and transitivity index to that of a random graph with the same number of nodes and links.² Since the average path length of a random graph is low and all nodes have few intermediaries between them in a small world, it follows that

²There are many ways to define a random graph. Following (Watts, 1999), we use simple expressions to calculate the transitivity and path length of a random graph that were derived from approximations of random graphs calculated on lattices. The τ of a random graph can be approximated as k/n , where n is the number of nodes and k is the number

as the PL ratio (PL of the actual network / PL of a random graph) approaches 1.0, the network begins to resemble a small world. In addition, in a random graph, since the clustering of nodes is low, the more the actual transitivity index deviates from the transitivity index in a random graph of the same size, or as the τ ratio (τ of the actual network / τ of the random graph) increasingly exceeds 1.0, the greater the degree to which the network resembles a small world. Or simply, the larger the small world quotient ($Q = \tau$ ratio / PL ratio), the greater the resemblance to a small world.

As the τ ratio rises, the links are increasingly made up of legislators who have previously cosponsored (i.e. repeated links/ties) or who have third-party cosponsors in common. This may occur because legislators who work on multiple bills are inclined to prefer cosponsors with whom they have cosponsored in the past or who have cosponsored with others with whom they have worked in the past, a process that is a result of reciprocity, partisanship, and reputation principles (Granovetter, 1973). The more a network exhibits the properties of transitivity, then, the more tightly knit the network is. Congressional “communities” or tight-knit groups might be formed through partisan leanings, gender, race, or caucuses that join members of Congress who work or are interested in a particular area of legislation. A highly clustered community is one in which the local community has more linked persons than a random graph of the same size.

When Q is low, there are fewer links between members of Congress or congressional communities and the links have low cohesion in the sense that they are not disproportionately formed through third-party or repeat ties among members of Congress. As Q increases, the network be-

of links. The average path length can be approximated as $L_M = D - \frac{k(k-1)^D}{(n-1)(k-2)^2} + \frac{k(D(k-2)+1)}{(n-1)(k-2)^2}$, where D can be approximated as $D = \lfloor \frac{\ln[\frac{k-2}{k}(n-1)+1]}{\ln(k-1)} + 1 \rfloor$, and where n and k are defined as above.

One alternative to this approach is to consider cosponsorship as a bipartite network between legislators as one set of nodes and bills as another set. For example, (Robins and Alexander, 2004) generate random networks that conform to the empirical distribution of the marginals of a bipartite network (in other words, in our case the random network would have the same distribution of cosponsorship activity by legislators and the same distribution of signatures on each bill). However, this is a conceptually different approach than we use here—we are interested in whether there are systematic patterns in the way legislators form working relationships with one another, not whether there are systematic patterns in the bills they choose to support. This means we should focus on the random alternative to the unipartite network of legislators instead of the random alternative to the bipartite projection when we are determining whether social path lengths and transitive social relationships are different than random.

comes more interconnected and connected by members of Congress who work together because there are more transitive relationships, and the links are disproportionately made up of repeat collaborators and collaborators who share common third parties. At high levels of Q , the small world becomes a very densely woven network of overlapping clusters. Many members of Congress or congressional communities are linked by more than one member of Congress and the relationships that make up the inter-community ties are highly cohesive. The community becomes more interlinked and linked by persons who already know each other. High levels of Q also imply a more bipartisan and cooperative culture.

2.2 Congress as a Small World

We computed the small world network statistics by year from 1973–2004 for the U.S. House of Representatives and the U.S. Senate. The cosponsorship data were originally collected from the Thomas database of bill summaries made available by the Library of Congress (Fowler, 2006). Although cosponsorship has been practiced in the Senate since the mid-1930s, and in the House since 1967, cosponsorship data in electronic format is currently available only from 1973 to the present. For the purposes of this study we include cosponsorship ties for the whole population of legislators in the House and Senate during this time period, drawing on all forms of legislation including all available resolutions, public and private bills, and amendments. Although private bills and amendments are only infrequently cosponsored, we include them because each document that has cosponsors contains information about the degree to which legislators are socially connected to one another.

A very large number of bills (156,270 or 55% of the total) are not cosponsored by anyone, so these bills do not provide information about social connections between legislators. The remaining 127,724 bills, however, each indicate which legislators were willing to work together. The average bill received 10.5 cosponsorships in the House and 3.4 in the Senate. However, the number of

bills cosponsored by each legislator does not differ systematically by chamber—the mean House member cosponsored 244 bills per Congress while the mean Senator cosponsored 250. While these numbers may seem large, they represent only a tiny fraction of the bills they might have chosen to support. The average House member cosponsored only 3.4% of all proposed bills and the average Senator cosponsored only 2.4%.

In the House, the transitivity index ranges from about 30% to almost 60%, meaning that two members of the House have a 30% to 60% (depending on the year) likelihood of cosponsoring the same bill if they have both cosponsored with a third common member of the House. The transitivity index for random graphs of the same size are always smaller meaning there is more clustering than one would expect due to random connections between individuals. The average transitivity index over this span of years is 0.457. The average path length for the various years spans from about 1.5 to just over 2, with an average path length of 1.74. For the corresponding random graph, the average path length is generally a bit larger, primarily hovering around 2 links. In addition, there is a good amount of variance in the small world quotient in these various years even between the two years that define a single Congress. This is not unusual as even when the actors do not change, their interactions should not be expected to be static.

The House and the Senate differ by institutional design, and so one might expect the behavior in these separate chambers to exhibit unique factors as well. These expectations are in fact borne out in the data. Both the characteristics of the transitivity index and the path length differ between the House and Senate, implying that contrasting social structures characterize the House and Senate. The Senate appears to be even more tightly knit than the House in that the transitivity index is much higher, ranging from over 46% to over 82%. The average transitivity index is 0.66, compared with 0.46 in the House. This is coupled with a path length that is always shorter, averaging just 1.3, versus 1.7 in the House. At the same time, because of the smaller size of the Senate, the random graphs of equal size exhibit higher transitivity indices. Interestingly, the Senate small

world quotient appears to peak in the late 1980s and early 1990s, a pattern that contrasts with the House.

3 Small World Impact on Important Legislation

We seek now to relate more formally how changes in the small world characteristics in Congress affect how it performs. Our analysis follows the highly influential work of Mayhew (2005). We move forward using Mayhew's model and data as a point of departure because of Mayhew's centrality to this literature and the importance of having a base model and data for comparison. Changes in the effect of any particular variable or the substantive implications of the model can be more easily interpreted when the models match the original model as closely as possible.

Accordingly, we begin by replicating Mayhew's analysis exactly for the time period that he examines (1946–1990).³ These results are shown in Column 1 of Table 1 where the data are analyzed, as Mayhew did, by Congress. The data are exactly the same set Mayhew used and the independent variables are defined in precisely the same manner. In particular, the divided government variable is a dichotomous variable indicating whether or not different parties controlled the Presidency, Senate, and House. The start of the term variable is also a dichotomous variable designed to capture the idea that more laws are likely to pass at the beginning of a presidential term, and is coded 1 for the first two years of a presidential term and 0 for the last two. Activist mood is coded 1 during 1961–1976 to match Schlesinger's "public purpose" (Schlesinger, 1999) and Huntington's "creedal passion" eras (Huntington, 1981). The historian, Arthur Schlesinger, identified periods of history where the U.S. was rooted in a national mood of public purpose (rather than private interest). These are periods where the government must intervene in order to ensure the protec-

³To be sure, Mayhew's analysis is not perfect. One point of contention has arisen over the stationarity of the data across time (Howell et al., 2000). Howell et al. (2000) conducted a battery of augmented Dickey-Fuller tests and showed that the data were not stationary. They included an appropriately fitted polynomial in time as an independent variable to render the data trend stationary. A Poisson regression was then run since the data are counts. Their conclusion was that "OLS regressions generate virtually identical results, though they do not fit the data as well" (Howell et al., 2000, 288). Therefore we stick to Mayhew's model as a "model standard" to maximize comparability.

tion of the common good, perhaps by attempting to redistribute wealth or to protect civil rights. Huntington describes the basic ideas of the American Creed as equality, liberty, individualism, constitutionalism, and democracy. He argues that periods of creedal passion describe historical periods of political reform and cultural uprisings in the United States. These times are characterized by general discontent around the country with a negative response to authority and a feeling that the government has strayed too far from the American creed. Lastly, the budgetary situation variable indicates the size of budget surplus or deficit as the percentage of government outlays.⁴

In the second column of the same table, we extend Mayhew's analysis to 2004 using his same variables and model specification, again using a two-year period as the unit of analysis. As we can see, the results for the extended time period (1946–2004) hold strongly to those reported in Mayhew (2005) despite the shorter time period he examined (1946–1990). The R^2 has declined somewhat for the data set with the additional 14 years, but the basic patterns stand the test of time, i.e. the significant variables remain significant and the substantive story does not change. In Column 3, for the same model specification, we restrict the Congresses we examine to the years for which we have cosponsorship data. Again, there is some decline in the R^2 value but the results do not change appreciably. Notably, the activist mood variable remains significant despite the much restricted time period examined and a fairly large change in the number of years that fall into the "activist mood" category (i.e., the 1960s, which were all coded as "activist mood" Congresses are not included). Lastly, even when we alter the analysis so that we examine each year rather than each Congress, the results (shown in Column 4 of Table 1) do not differ much. The activist mood variable remains significant.

[Table 1 about here.]

⁴We note that several of our variables are ratios or proportions of ratios. Accordingly, some caution should be taken because of validity issues that may arise from this data peculiarity. For instance, the data aggregation method used to compute the transitivity index creates a mean of the individual transitivity indices, already a proportion, and thus hides information about distributional effects. One might gain from paying closer attention to the distribution of the transitivity values, since ties can be distributed in dramatically different ways within a neighborhood (e.g., clumped versus uniform). It would be interesting to explore whether or how different distributions of data may reflect different political processes. Our data aggregation method does not allow us to tap into this richness in the data.

Since cosponsorship was not practiced in the House during this entire time period (1946–2004), we cannot compare our results directly to those reported by Mayhew. However, as demonstrated by the results in Table 1, the basic Mayhew results remain across various time periods in Congress and even from an examination of entire Congresses (i.e. two year periods) to an examination of single years. Hence, our point of departure need not mirror exactly the original Mayhew specification either in overall time span or in examining two-year Congresses. We choose to examine yearly data for several advantageous and critical reasons. First, it allows us to keep the total number of observations in the range of 30. Second, there is a substantial amount of data within each year given the large number of bills proposed yearly that need not be lost in aggregation. Third, we have substantial variation that can be exploited in both the budgetary situation and the small world quotient even within a single Congress. Our point of departure then is shown in the column 4 results of Table 1 (the yearly data from 1973–2004). Notice that these estimates are in agreement with Mayhew’s (2005) results and further maximize the time period for which we are able to compute our social network statistics.

[Table 2 about here.]

The Mayhew results are striking and the specific impact of divided government is somewhat counterintuitive. The basic hypothesis underlying our analysis is that “successes” in Congress are related not only to characteristics of Congress, but to the social dynamics of Congress as well. That is, all else equal, greater interconnectivity in the cosponsorship network leads to increased productivity of the Congress as a whole. We extend the analysis in Table 2 to explore the role of social dynamics. Column 1 lists the results when we retain Mayhew’s basic model specification but add the small world quotient. Interestingly, Mayhew’s activist mood variable, which has remained significant through multiple subsets and various time periods of data, is no longer significant when we include the small world quotient for the U.S. House. Instead, the only significant variable is the small world quotient. The positive and significant sign on the small world quotient

indicates that Congress passes more important legislation as the Congressional network becomes a smaller and smaller world. The specification in Column 2 adds in the small world quotient for the Senate. The small world quotient for the Senate is not significant and does not appear to improve the model fit even marginally. Perhaps this result is due in part to the generally much higher levels in the transitivity index and the smaller path lengths in the Senate. That is, at some point, it may be that a threshold has been crossed where becoming an even smaller world is less consequential. Indeed, the Senate is a different political institution because of its smaller and more intimate size, longer terms, and greater visibility.

There are many possible model specifications, and it would be ideal if we could control for many different variables. However, our model specifications are constrained by the relatively small number of observations, which limits our degrees of freedom and thus the numbers of variables it is reasonable to include in a single model specification. Accordingly, we must be judicious in our choices. One important decision is whether the small world measure should be the network measure of choice given the many other ways to characterize graphs. The small world property depends simultaneously on transitivity being strong and average path length being short. Transitivity and path length are two of many ways to characterize graphs and the ratio of these entities is but one means to assess a characteristic of these congressional networks. Columns 3–6 of Table 2 explore some alternative specifications. In particular, we examine the effect of triads alone (column 3), path length alone (column 4), graph density (column 5), and transitivity and path length together, but not as a ratio as in the small world measure (column 6). Columns 3 and 4 show that both triads and short path length help to explain legislative productivity, and quite significantly so. Graph density does not have quite the same effect, is not significant, and activist mood remains significant in the specification that includes graph density. Interestingly, when both the transitivity index and average path length are included together in a specification, nothing is significant. The R^2 is elevated despite the lack of statistical significance in the individual regressors. These

are classic symptoms of multicollinearity. In fact, it does appear that the transitivity index and the average path length are highly negatively correlated ($\rho = -0.91$, implying a small world structure where short path lengths are generally associated with high transitivity levels). Accordingly, column 1 with the small world measure is the preferred specification because it allows us to include two measures that are apparently relevant but combines them in such a manner as to allow their inclusion without the problems associated with multicollinearity.

Another consideration is that the model specifications we have discussed thus far, like Mayhew's, do not account for the volume of legislation. One might guess that the number of important laws passed would be related to the size of the legislative agenda (Binder, 2003). This amounts to a slightly different question but certainly is a plausible hypothesis and should ideally be tested as well. In the first two columns of Table 2, we attempted to follow, as closely as possible, Mayhew's analysis. Mayhew (2005) argues that the important element in his analysis is the numerator (i.e. the number of important laws passed) and not the denominator (i.e. a ratio of the number of important laws passed to the size of the legislative agenda). Others (Howell et al., 2000; Binder, 2003) have argued that a "denominator" approach is important to developing an understanding of success or gridlock in Congress. The last column of Table 2 displays a model specification aimed at this alternative formulation. In the third column, the dependent variable is the number of important laws passed (from Mayhew) divided by the total number of issues on the agenda in each Congress, the denominator advocated by Binder (2003).⁵ Binder's values are available only by Congress and not by year since Congress's productivity is typically assessed by what they accomplish as a Congress (i.e. a two-year period). It is not possible to disaggregate her data to the year-level because of how her database was constructed. Conducting an analysis by Congress cre-

⁵The results displayed are from using the "gridlock 3" variable. She supplies 5 different gridlock variables. Gridlock 1 includes the widest range of issues. It includes issues that were featured in at least one editorial, and so includes the widest range of issue salience. The other four gridlock variables include fewer issues depending on level of salience. Gridlock 5 includes issues that received five or more editorials and thus were more salient. Binder's analysis is often conducted for all of her gridlock variables. The analysis here results in a significant small world Q coefficient when we use any of her gridlock variables and so our choice of displaying the gridlock 3 results is of no consequence. Note that the gridlock 2, 3, 4, and 5 variables are highly correlated (between 0.87 and 0.96) while the gridlock 1 variable including the most issues displays lower correlation values with the other four.

ates an obvious difficulty—reducing the sample size by half. Binder’s data, moreover, is available only until 2000, not 2004, reducing the sample size further. Since we already have a somewhat small set of observations to begin with, the sample size problem is acute. To preserve what few degrees of freedom remain, we conduct the analysis by year but use her values for two years. That is, 1973 and 1974 have the same value for the gridlock variable, 1975 and 1976 have the same values, and so on. This model, accounting for the size of the legislative agenda, again accords with our main result—small world characteristics are significantly related to legislative productivity. Thus in spite of severe limitations on the data, the connection between the dynamics of the small world and legislative productivity remain through several different specifications.

4 Discussion

We have uncovered an intriguing connection between small world characteristics and the production of important pieces of Congressional legislation. We need to untangle this quantity in order to get a sense of what this connection entails. To begin, however, let us emphasize that what appears to be uncontroversial in this connection is that social relationships would be connected to legislative productivity. Congress is not 535 members working in isolation of one another, affected only by outside forces such as the “start of term,” the budgetary situation, or whether there is an “activist mood” pervading the session. How well the members of Congress work together has an impact on the efficiency and productivity of Congress. The dynamic social relationships—constant maintenance of older established relationships and forging relationships with new members of Congress—matter. And the small world quotient taps these social phenomena in Congress.

What do these small world characteristics in Congress indicate? One interpretation is that cosponsorship is but one of many forms of communication that will be affected by the underlying social structure. When communication is easy and simple, the likelihood of effectiveness and success in a shared endeavor increases. When friends are friends with friends, what emerges is a

system where communication is enhanced because commonalities are reinforced and the number of paths through which information flows increases in number. In addition, barriers are broken down by the nature of the system—enlarged and numerous existing friendship circles. But the modularity of the network is also important. A well-known regularity in prisoner’s dilemma games in social networks is that clustering increases the likelihood of cooperation since it permits the evolution of reciprocity and trust (Ifti, Killingback and Doebelic, 2004). In Congress, the dynamics are similar (Baughman, 2006). Low values of the small world quotient indicate that members of Congress are more isolated and fewer are willing to extend support outside their local networks of friends and supporters. As the world gets smaller, the friendship circles that define relationships and interactions begin to break down barriers such as partisanship. As communication is enhanced, links become increasingly dense, and the distance between any two members of Congress declines. Congress becomes more efficient, more cohesive as a legislative body, and a more effective conduit for passing important pieces of legislation.

Moreover, as the numbers of links that exist between members of Congress rises, not only is communication strengthened, but we see an increase in and an enhancement of the channels through which other types of “legislation enhancing” elements can flow. Creativity, for instance, both in terms of content as well as in methods for reigning in support, is enhanced. The transfer of ideas which is more difficult when the number of actors is large and disjointed is also facilitated in the small world setting. Allegiances are built and strengthened. Conditions conducive to reciprocity are established and can either be built upon immediately or leveraged for later use. These conditions are reinforced as the links become increasingly transitive.

When the small world quotient is low, the members of Congress are more isolated. Moreover, the links that exist do not indicate the same type of cohesion since they are not disproportionately formed through common third party cosponsors. So, while links exist and bills are certainly cosponsored among various congressional teams or communities, the impact of the structure is

not surmised simply by counting the number of cosponsorships (as indicated by the lack of significance in the graph density coefficient). Our method of measuring small worlds controls for legislative activity by normalizing real network observations to a hypothetical network with the same number of relations that are randomly distributed. Random networks will have low path lengths between individuals, but they do not have the same strong clustering that occurs in real networks. Granovetter (1973) first noted that the existence of “weak ties” between these clusters are critical for individual and organizational success, so it is hardly surprising that we find the types of links that make up small world systems are especially prevalent in effective Congresses. Indeed, all cosponsorships are not equal or comparable in their impact upon Congress’s ability to pass important legislation. Instead, the types of links that make up small world systems are especially prevalent in effective Congresses.

Of course, all of these relationships exist in degree. We are extremely unlikely to ever experience a perfectly connected or completely disjointed Congress. As the distribution of connections and cohesion changes, the dynamics in Congress change. As the world gets smaller, the structure of support for passing important legislation is strengthened. The structure, as well, shapes resources since large tightly-knit teams command different resources than small isolated teams. Undoubtedly, the dynamic is complex and multi-faceted.

Although the results here suggest the existence of a significant relationship across several specifications, further research is needed to explore the causal mechanisms that yield improved cooperation in Congress. Could the small world quotient simply be a proxy for some other better-known quantity such as degree of partisanship, party polarization, or ideological polarization among individual members? This is a complex question and fleshing it out completely is beyond the scope of this study, but we do note that the party polarization measure from McCarty, Poole and Rosenthal (2006) appears not to be tied to the small world quotient. For the House, the correlation between the party polarization measure (by Congress) and the small world quotient (by

Congress) is -0.17. A simple bivariate regression between the two quantities shows that the McCarty et al. measure explains virtually none of the variance in the small world quotient. The R^2 value is 0.029 and the adjusted R^2 is negative. The coefficient is not significant. This suggests that the small world quotient is capturing changes in social relationships that are not due to increasing ideological or partisan polarization. Likewise, the small world measure is not highly correlated with any of the other variables in our model. We also know that simply increasing the number of cosponsorships is not effective since the graph density variable was not significant. So it is the *relationship structure* (i.e. the interconnected triads) captured by our small world measure, and not simply a rise in the number of cosponsorships, that increases congressional productivity.

We also note that the data in our study have been subject to aggregation. We have taken data on individual Members of Congress and aggregated them over the entire Congress. Surely, much information is lost in the aggregation process, and there is much to be gained from increasing the granularity of the data or even from examining different levels of aggregation. In future work we hope to shift the focus from the aggregate to the individual level. In this article, although we have been concerned with the macroscopic structure of the relationships legislators form with other legislators, we recognize an important and complementary question is the extent to which we can use the bipartite version of the network of legislators and bills to learn how legislators make decisions about specific legislation. This work may also help us to understand better the specific causal mechanisms that contribute to the relationship between small worlds and legislative success. In other words, this study truly represents a first step and sets the foundation for a more extensive literature that seeks to delineate the factors lead to a small world and further attempts to understand the role of social connectedness in the effectiveness of Congress. Identifying and illuminating these processes may help us to design institutions that will enable legislatures to promote the types of social interactions that lead to the production of important legislation.

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Figure 1: **Transitivity Index, τ**

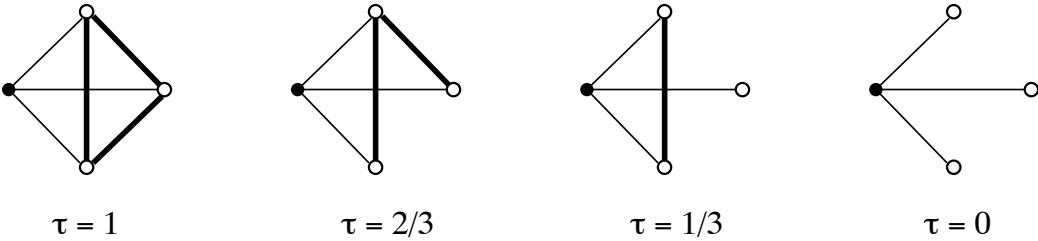


Table 1: **OLS Regression. Dependent Variable: Legislative Productivity. Examination of Various Changes in the Mayhew Specification.**

	1946–1990 (by Congress)	1946–2004 (by Congress)	1973–2004 (by Congress)	1973–2004 (by year)
Intercept	7.90* (1.01)	7.56* (0.99)	7.84* (1.71)	4.54* (1.04)
Divided Government	-0.59 (1.12)	0.18 (1.04)	1.49 (1.69)	0.38 (0.96)
Start of Term	3.47* (1.07)	3.29* (1.05)	2.48 (1.63)	1.05 (0.82)
Activist Mood	8.52* (1.12)	8.20* (1.20)	8.91* (2.59)	3.98* (1.26)
Budgetary Situation	0.05 (0.06)	-0.00 (0.00)	-0.00 (0.00)	0.00 (0.05)
<i>N</i>	22	29	16	32
<i>R</i> ²	0.80	0.70	0.55	0.31
Adjusted <i>R</i> ²	0.76	0.65	0.39	0.21

Standard Errors in Parentheses.

* $p < 0.05$

Table 2: OLS Regression. Dependent Variable: Legislative Productivity.

	1973-2004	1973-2004	1973-2004	1973-2004	1973-2004	1973-2004	1973-2000
Intercept	-10.31 (5.11)	-17.32 (12.99)	10.21* (2.70)	-6.52 (5.06)	6.63* (1.43)	2.68 (19.35)	-0.37 (0.21)
House Small World Q	7.39* (2.50)	9.04* (3.78)					0.27* (0.10)
Senate Small World Q		1.87 (3.19)					
House Transitivity Index			-13.01* (5.78)			-7.50 (15.20)	
House Path Length				6.37* (2.86)		2.95 (7.51)	
House Density					-10.22 (5.07)		
Divided Government	0.31 (0.85)	0.69 (1.07)	-0.49 (0.98)	-0.09 (0.92)	-0.02 (0.93)	-0.34 (1.06)	-0.03 (0.04)
Start of Term	1.28 (0.73)	1.33 (0.74)	1.09 (0.76)	1.18 (0.77)	1.09 (0.78)	1.13 (0.78)	-0.02 (0.03)
Activist Mood	1.98 (1.30)	1.91 (1.32)	2.47 (1.36)	2.15 (1.44)	2.94 (1.30)	2.26 (1.48)	-0.05 (0.05)
Budgetary Situation	0.03 (0.05)	0.05 (0.06)	-0.04 (0.05)	-0.01 (0.05)	-0.01 (0.05)	-0.03 (0.06)	0.00 (0.00)
N	32	32	32	32	32	32	28
R^2	0.48	0.49	0.42	0.42	0.40	0.43	0.28
Adjusted R^2	0.38	0.38	0.31	0.31	0.29	0.29	0.11

Standard Errors in Parentheses.

* $p < 0.05$