

Political Polarization Within the U.S. Congress

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1 Introduction

The phenomenon of polarization, especially in US politics, has been widely discussed and examined from many different angles. In recent years, this topic has become especially relevant as polarizing figures have emerged as prominent leaders.

There is no clear answer on what it means for polarization to be increasing. No obvious measure exists, which has made this question nuanced and difficult to clearly understand. Many different ways of researching this topic have been proposed. For example, a 2014 study done by Pew Research Center has been widely cited as they were able to show through survey data that the general population's political opinions have diverged through time, leading to increased ideological uniformity [Dimock et al. 2014]. In addition to survey data on political opinions, social media data has been used to study how people are increasingly getting into informational silos where their viewpoints are repeated and solidified. This is consistent with the psychological phenomena confirmation bias, referring to the tendency to seek out information that already agrees with our pre-existing beliefs. These are all valid ways of studying the phenomena of polarization, but we want to also explore how this polarization has translated in terms of lawmaking institutions within the US.

The idea of polarization within US Congress is explored in Neal 2020 where a co-sponsorship network is created and analyzed to see whether weak and strong polarization has been on the rise from 1973 to 2016. The author uses patterns of bill co-sponsorship to infer positive and negative ties between and within parties in Congress. The main findings are that polarization, both weak and strong forms, has been on the rise since the 1970s. Additionally, polarization trends are unrelated to which party holds the majority.

In this project, we examine polarization by first recreating the results from the paper using the years 2003 to 2023. We then look at co-voting patterns using a similar methodology. Finally, we run some analyses to see whether there are any associations between Congressional representatives being more central in the network and being able to push bills further through the legislative process or being able to garner more bipartisan support for their bills.

2 Background

Political polarization within the United States has become a huge topic for research in recent years. It is often defined as a general shift towards a specific political attitude or party's ideology which ultimately produces a divided political atmosphere. As time progresses, Republicans and Democrats appear to be more and more ideologically distant from each other, creating more hostile and unproductive political and cultural institutions.

There are many drivers that influence the reasons why polarization has increased. These may include gerrymandering, or political manipulation of electoral districts to give one party an unfair advantage in elections. Additionally, the rise of geographical sorting and an overall increase of activism of parties have been cited as drivers of polarization. Regardless of the various reasons that could be contributing to polarization, the goal of this project is to study the claim of *increasing* polarization through the use of Congressional data.

In Neal 2020, the author explores the claim of increasing polarization by using data from the legislative branch of the US government. Using co-sponsorship networks between members of the Senate and the House of Representatives, inter-group relations are established and used to examine two forms of polarization: weak and strong. **Weak polarization** refers to a situation where positive relations exist *within* each political party but there is merely an absence of positive relations *between* different parties,

as in 1a. **Strong polarization** takes the weak polarization definition a step further, requiring there to not only be positive links *within* parties, but also negative links *between* different parties, as shown in 1b. Zachary Neal has described this as an “us versus them” situation, where Democrats and Republicans do not work together in the lawmaking process and are solely interested in different issues [Neal n.d.]. When there is evidence of strong polarization, there exists what he terms as “in-group favoritism with out-group derogation”. There could be many reasons for the existence of negative links between legislators. For example, political competition, differing agendas, and animosity could lead to Congressmen supporting different legislation. Figure 1 shows this relation more clearly.

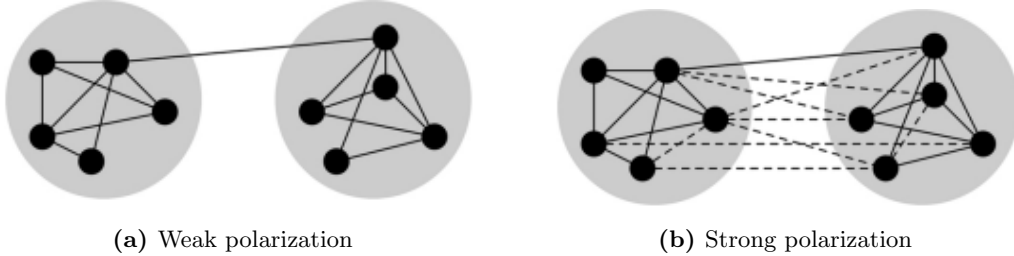


Figure 1: Two forms of polarization defined in Neal 2020.

In his paper, Neal explains that although there are many potential ways of measuring polarization, such as observing legislators’ committee co-memberships or voting patterns, Neal opts to use co-sponsorship networks. Firstly, he applies the Stochastic Degree Sequence Model (SDSM) in order to infer the signed political relationships among legislators. This model takes an unweighted bipartite graph, B , and compares each edge’s observed weight in the projection $B * t(B)$ to the expected weight in a random bipartite network projection. The observed number of co-sponsorships between two legislators is compared to the random projection and (with a significance level of 0.05) the null hypothesis is rejected or accepted. The edges of the resulting matrix are 1 if two legislators jointly co-sponsor considerably more bills than expected, -1 if they jointly co-sponsor considerably less bills than expected, or 0 if the null hypothesis is accepted.

In figures 2, 3, 4, the main results from Neal’s paper are shown. Neal firstly examines the general trend of positive and negative links between legislators regardless of party, in 2. He finds that there are more than twice as many negative links as positive ones, and that this pattern is slightly increasing with time.

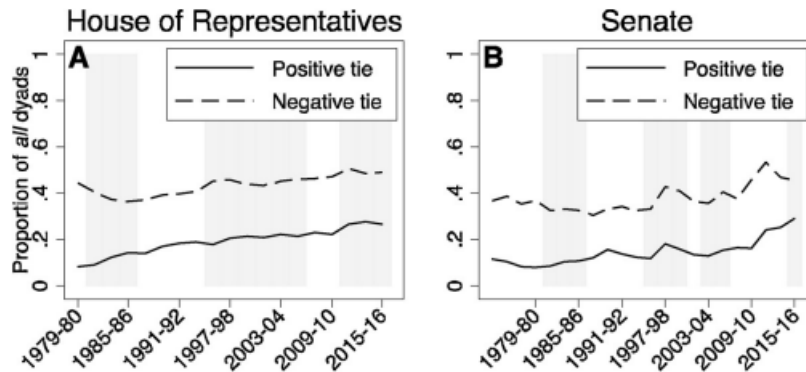


Figure 2: Proportion of all dyads linked by a positive or negative edge, Neal 2020.

Next, in figure 3, Neal shows that positive links are predominantly within the same party, while negative links are usually between parties. These graphs are the main result of the paper that show the increasing polarization. The solid line showing positive within party links increasing shows that weak polarization is on the rise. The dashed line shows that indeed negative between party links are also increasing through time. The combination of both the solid and dashed line increasing provides evidence that strong polarization is increasing as well.

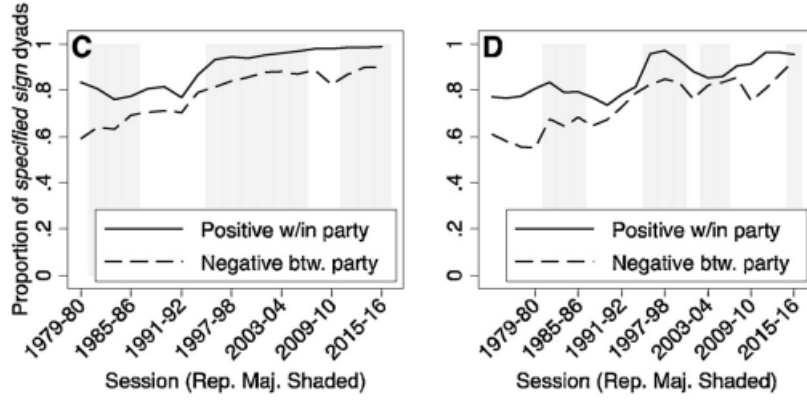


Figure 3: Proportion of positive links that are within party and proportion of negative links that are between parties, Neal 2020.

Lastly, in figure 4 negative within party ties as a proportion of total within party ties is shown separately for Democrats and Republicans. Surprisingly, when a party holds the majority, negative ties inside the party appear to be more prevalent, suggesting that majority-party lawmakers are more likely to create divisions that might impair the party's ability to promote its policies.

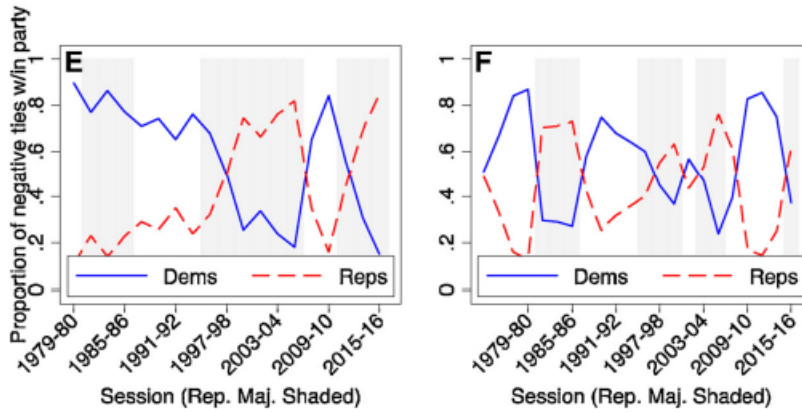


Figure 4: Proportion of within-party negative links that occur between two Democrats or Republicans, Neal 2020.

In order to visualize the the weak polarization trends, a graphical representations of positive co-sponsorship links, called sociograms, were created in the paper. The analysis compares two periods, the 1979-80 session and the 2015-16 session, with Democrats, Republicans, and Independents represented in blue, red, and green respectively. In the 1979-80 session, there was some evidence of weak polarization with Republicans and Democrats favoring to work within their party. However, separation between these clusters was not as obvious. By 2015-16, weak polarization can be visually seen to have become more extreme, with Republicans and Democrats maintaining positive links almost entirely within their own parties. This clear separation between the clusters can be seen in figure 5.

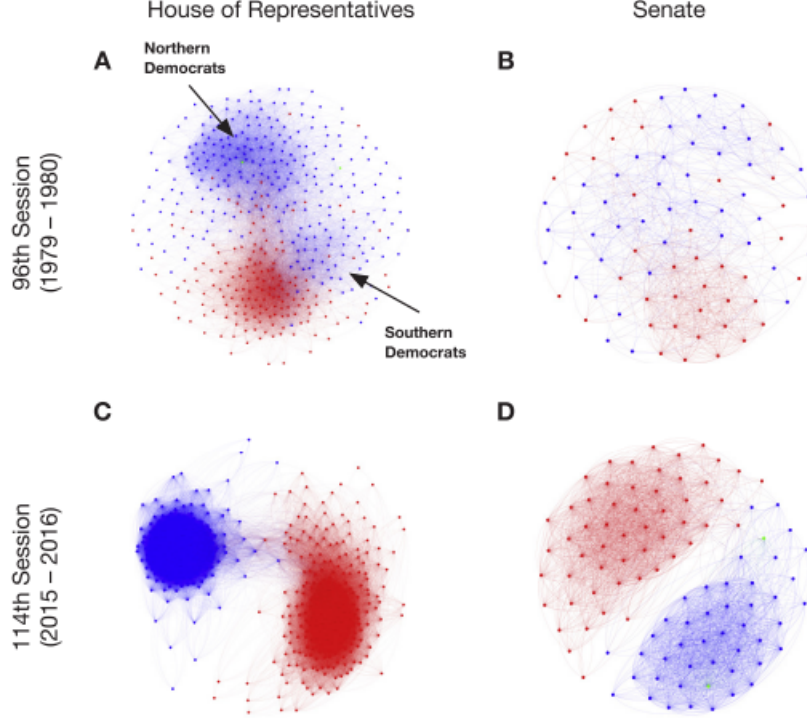


Figure 5: Positive links between legislators of different parties Neal 2020.

Neal 2020 is a pivotal paper exploring the nature of political polarization, although more comprehensive research is needed. We aim to replicate and expand upon Neal’s methodology using the years 2003 to 2023. The Methods section details the methods we use and the Results section details the results and analyses of our project.

3 Methods

In this project, we use a similar methodology as Neal 2020. From the *incidentally* package [Neal, Zachary P 2022] in R, we extract the incidence matrices for Congressional co-sponsorships from the 108th to the 118th Congress. We do this for both chambers of the Legislative Branch, the House of Representatives and the Senate. For the House of Representative, we extracted all House Bills (hr) and all House Joint Resolution (hjres). We note that we opted not to include House Concurrent Resolutions (hconres) or House Simple Resolutions (hres) because they are mainly used for procedural matters and thus do not have the force of law, as they do not require the approval of the other house nor the president. Similarly, for the Senate, we extracted all Senate Bills (s) and Senate Joint Resolutions (sjres), but we omitted Senate Concurrent Resolutions (sconres) and Senate Simple Resolutions (sres).

Each incidence matrix, $B_{S,C}$, corresponds to a specific session, S , and chamber of Congress, C . $B_{S,C}$ has rows corresponding to Congressmen and columns corresponding to bills introduced in the relevant session. Each entry, b_{ij} , is equal to 1 if Congressman i sponsored (or co-sponsored) bill j , or is equal to 0 if Congressman i did not sponsor/co-sponsor bill j . We also obtained metadata on both the legislators and the bills for each Congressional session and chamber. This metadata included id, name, party, and state for each Congressman. Additionally, for each bill, the metadata included the bill id, date introduced, title, policy area, sponsor party, number of cosponsors from each party, and status of bill. We note that the incidence function was failing to pull the House resolution (“hr”) bills for the 116th session, so the data was only based on 388 bills that were house joint resolution (“hjres”) bills. For this reason, the 116th Congress is omitted from the House analysis.

After obtaining all the incidence matrices, we extracted the backbone matrices using the Stochastic Degree Sequence Model (SDSM) from the *backbone* package [Zachary P Neal 2022] in R. SDSM evaluates the weight of an edge in the $B * t(B)$ projection by comparing it to the weight distribution expected in a projection derived from a randomly generated bipartite network. The resulting output is a signed matrix where each entry, corresponding to each pair of Congressmen is the result of a two-tailed test

measuring whether the weight is significantly different (weaker or stronger) than the random bipartite network weight. This resulting backbone matrix yields positive edges ($= 1$) for edges that are significantly stronger and negative edges ($= -1$) for edges whose weights are significantly weaker than expected in the chosen null model.

Using the backbone matrices and the metadata available we recreated the figures from Neal 2020 and performed some regression analyses that are outlined in the following section. Additionally, to extend the analysis we apply the same methods using SDSM to a co-voting network by extracting votes for each bill per individual congressman and creating the incidence matrix for each Congress from the first to the current one. We recreated the figures from Neal using the co-voting networks and compared and contrasted the results.

4 Results

4.1 Replication of Figures, 2003 to 2023

The following figures show our recreation of the plots from Neal 2020, but with the extended Congressional sessions. Neal’s work ended in 2016, but our graphs show the extension of the analysis by including the years 2003 to 2023. In all graphs, the years when Republicans had a majority in the respective chamber are shaded in red for reference.

Figure 6 shows the proportion of all edges that have positive (solid lines) or negative links (dashed lines). The graph shows a very slight, steady increase in both positive and negative links for the period assessed. This is consistent with Neal’s findings, shown in 2 above.

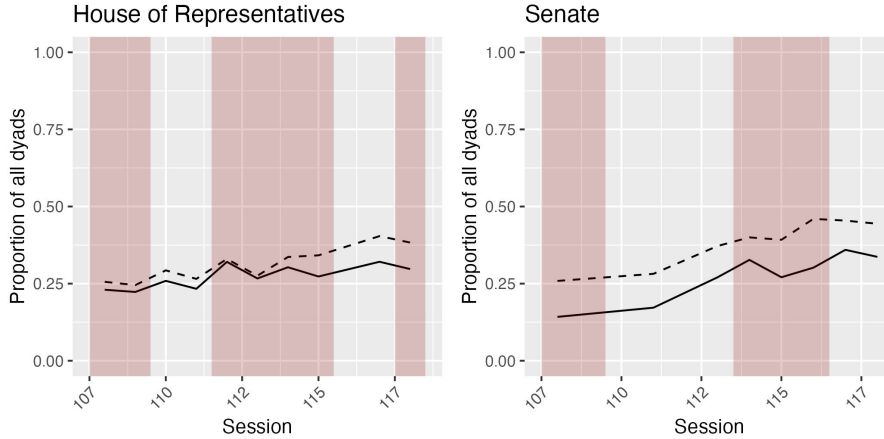


Figure 6: Proportion of all dyads with positive links (solid line) and negative links (dashed line) for both chambers of Congress (Republican majority years shaded in red).

Figure 7 shows weak and strong polarization trends. The solid line in each graph shows the proportion of all positive edges that occurred between members of the same party. In both graphs, the solid line is increasing through the period, indicating a steady increase in *weak* polarization. For the 118th Congress, the current session, the proportion of positive links within parties is about 99.9% for the House of Representatives and about 95.7% for the Senate. This means that nearly all positive links in the network occurred among legislators within the same party. This fact in and of itself shows us how polarised US Congress has become, with positive relations almost exclusively being seen within parties.

Strong polarization seems to be similarly on the rise. The dashed lines in both graphs in figure 7 show the trend of proportion of negative ties between members of opposite parties. Again, it seems to be on the rise. For the 118th Congress, the proportion of negative links between parties is about 95.7% for the House of Representatives and about 92.8% for the Senate. Once again, these rates have become so high that almost all negative ties were between members of opposite parties. Legislators seem to have increasingly continued to divide along party lines and refuse to work with members outside of their political ideology. Similarly, Neal’s graphs show a steady upward rise in weak and strong polarization. Our graphs illustrate that the polarization trends continue upwards until 2023 and are even near the limits of how polarised they can be using this definition.

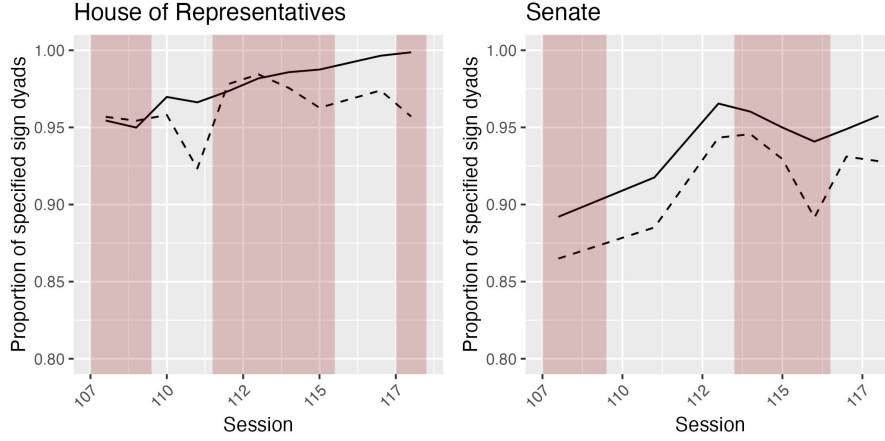


Figure 7: Proportion of positive ties *within* parties and negative ties *between* parties (dashed line) for both chambers of Congress (Republican majority years shaded in red).

Figure 8 shows the proportion of negative ties *within* party for each party separately. These rates are clearly very low because members of the same party tend to work together, but it is nevertheless interesting to examine when the upward spikes occur. For the House of Representatives, the trend can clearly be seen that the party in power tends to have more within-party negative ties than the other party. This makes sense as legislators may have more leeway to disagree with and not work with members of their own party when they are in power. For the Senate graph, the relationship is not as clear as the Republicans and Democrats tend to move together in the proportion of within-party negative ties.

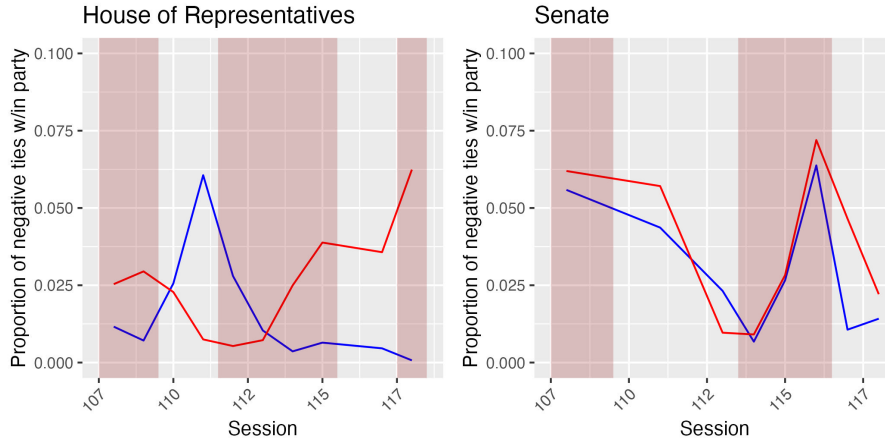


Figure 8: Proportion of negative ties *within* party for Republicans (red line) and Democrats (blue line) for both chambers of Congress (Republican majority years shaded in red).

4.2 Analyzing Co-voting Patterns

To extend the analysis we apply the same method to a co-voting network. By extracting votes for each bill per individual congressman we are able to create an incidence matrix for each congress. We are able to extract data from the first Congress until today. With this data, we recreate the figures presented above. As the data did not provide a clear separation between Democrats and Republicans across time, we opted to omit the proportion of negative ties within party. Note that for the purpose of this project the proportion of specified signed dyads is the biggest point of interest. We provide the visualization for both all periods in one graph and a zoomed in graph showing the 108-118 Congress only to better understand recent trends.

Figure 9 shows that in the co-voting networks across all time there was increasing trend in both positive and negative ties within the network. Looking closer at recent years, however, we see that unlike in the co-sponsorship networks, the proportion of these ties no longer increases but rather stabilizes at 0.5 for both positive and negative relations.

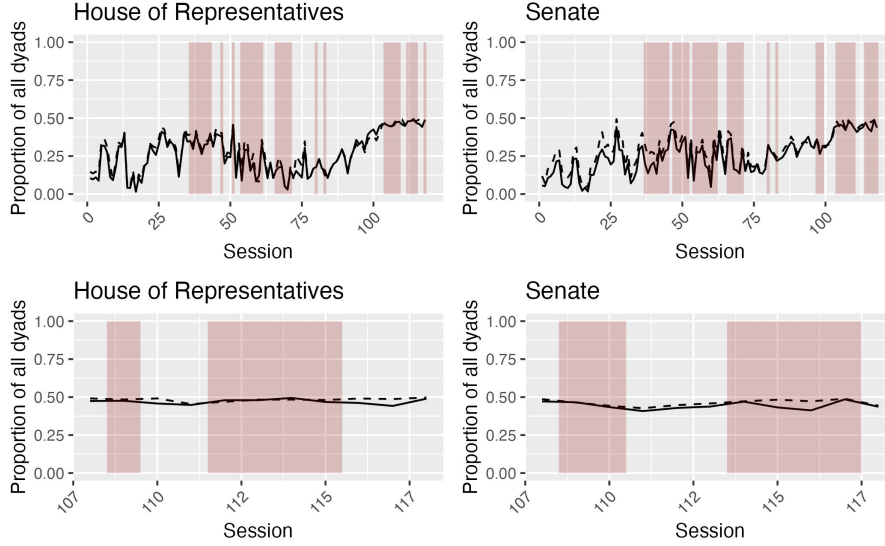


Figure 9: Proportion of all dyads with positive links (solid line) and negative links (dashed line) for both chambers of Congress (Republican majority years shaded in red) extracted from co-voting networks

Figure 10 shows the weak and strong polarization trends extracted from the co-voting networks. We once again see the increasing trend throughout the longer time period. In the recent years, there is a slight upward trend present in the House of Representatives networks, however no upward slope is detected in Senate. The negative ties between parties have higher proportions at all times than positive ties in the House of Representatives. In Senate this no longer applies and we can see that both values decrease, which could be a result of within party splits caused by different beliefs, such as supporting polarising presidents or controversial topics. Both proportions remain at around 90% for Senate and 95% for House of Representatives which still indicates high polarization in these governmental bodies.

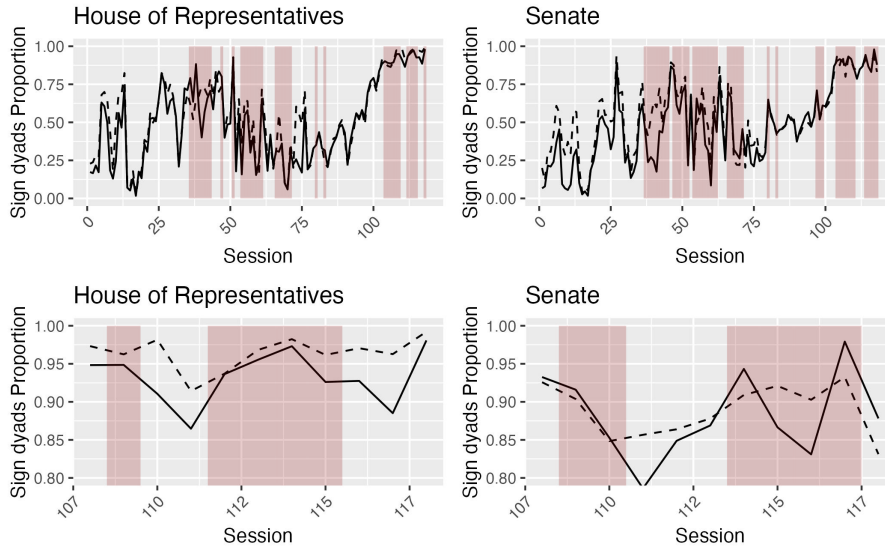


Figure 10: Proportion of negative ties *within* party for Republicans (red line) and Democrats (blue line) for both chambers of Congress (Republican majority years shaded in red).

We were however unable to connect this data with the co-sponsorship networks. This is because the joining would require a lot of pre-processing for numerous reasons such as bills do not have a unique bill ID but are repetitive, confounded bills are not always voted on, there is not a 1-to-1 relationship between the databases. the kind of information available after joining these two information sources could potentially provide additional insights into the trends within Congress and this remains as a future work.

4.3 Regression Analysis and Discussion

As an extension to our results from the co-sponsorship analysis, we performed several regression models in an attempt to answer a few key questions. Mainly, we are interested in the role of Bonacich centrality in bill co-sponsorships and bill passage.

4.3.1 Centrality and Bill Passage

Firstly, we wanted to see whether centrality can play a role in bill passage. Our metadata includes the status of each bill, categorized into groups as *Introduced*, *Passed senate*, *Sent to president*, and *Became law*. This order reflects a bill’s progression through the legislative process, with *Became law* being the optimal scenario for a legislator who introduced that bill. Therefore, our first question is as follows: “Do senators with higher Bonacich centrality achieve greater bill passage or at least advance bills further through the legislative process?”

The model we are running is as follows:

$$status_{C,S,i} = \beta_{0,C,S} + \beta_{1,C,S} \times bonacich_{C,S,i} + \epsilon_{C,S,i}$$

In the equation above, *status* is the status of the bill through the legislative process. It is given as an integer representing how far each bill went, namely *Introduced*, *Passed senate*, *Sent to president*, or *Became law*. The independent variable, *bonacich*, refers to the bonacich centrality measure of the main sponsor for each bill. Several different chambers (*C*) and sessions (*S*) are shown, and a variety of years were chosen so that there would be a mix of Republican and Democratic-led Congress sessions. The results of the five models are summarized in table 1.

Chamber (C), Session (S)	$\hat{\beta}_1$	Std. Error	p-value	Adj R^2	F-statistic
Senate, 108th	0.0454	0.0186	0.0145 (*)	0.00162	5.98
House, 108th	-0.0426	0.0229	0.0631	0.00047	3.46
Senate, 117th	-0.0034	0.0094	0.7210	-0.00016	0.13
Senate, 118th	0.0009	0.0041	0.8280	-0.00043	0.05
House, 118th	-0.0119	0.0058	0.0385 (*)	0.00077	4.29

Table 1: Results of regression models for 5 models regarding centrality and bill passage for specific chambers and sessions.

As we can see in 1, the results of the regression models do not provide overwhelming evidence to support the hypothesis that bills which have a more central main sponsor get further through the lawmaking process. There is one model with a significant positive coefficient $\hat{\beta}_1$ and one with a significant negative $\hat{\beta}_1$. The significance level is only at 10% though, and with the very low adjusted R^2 values in all the models, there is little evidence that this model can capture all the variability in bill status. There wasn’t much other metadata we were able to add to the regression models to take this analysis further so analyzing this question further with additional data remains as a future work.

4.3.2 Centrality and Co-Sponsorships from Opposing Parties

Next, we wanted to see whether higher centrality of the main sponsor of a bill plays a role in co-sponsorship by members of the *opposing* party. The hypothesis is that legislators who are more central in the network may possess the ability to garner greater support from their political adversaries, whether through leveraging favors or due to their influential status within Congress. Namely, the second question is: “Do Congressmen with higher Bonacich centrality have a higher likelihood of attracting co-sponsorship from members of opposing parties for their bills?”

The model we are running for this second question is as follows:

$$cosponsors_{C,S,i} = \beta_{0,C,S} + \beta_{1,C,S} \times bonacich_{C,S,i} + \epsilon_{C,S,i}$$

In the equation above, *cosponsors* is the number of opposing party co-sponsors for each given bill. For example, for a given chamber (*C*) and session (*S*), if bill *i* has a main sponsor from the Republican party, *cosponsors*_{*C,S,i*} represents the number of Democrats and Independents who co-sponsored bill *i* as well. The independent variable, *bonacich*, refers to the bonacich centrality measure of the main sponsor for each bill. The results of the five models are summarized in table 2.

Chamber, Session	$\hat{\beta}_1$	Std. Error	p-value	Adj R^2	F-statistic
Senate, 108th	0.2462	0.0934	0.0084 (**)	0.00193	6.95
House, 108th	-0.6834	0.4420	0.1220	0.00025	2.39
Senate, 117th	0.1362	0.0405	0.0008 (***)	0.00190	11.31
Senate, 118th	0.1183	0.0682	0.0830	0.00089	3.01
House, 118th	1.3258	0.3460	0.0001 (***)	0.00313	14.69

Table 2: Results of regression models for 5 models regarding centrality and co-sponsorships from opposing parties for specific chambers and sessions.

Once again, from 2, the results of the regression models do not provide substantial support for this hypothesis. However, several of the coefficients in these models are more significant, providing some additional support that centrality of the main sponsor could play at least some role in how many co-sponsors from opposing parties join to co-sponsor a bill. Although some of the coefficients show some promise to support the hypothesis, this analysis could benefit from expanding the scope of the question and introducing additional variables to better examine the complex relationships at play in the legislative process.

5 Conclusion

We have examined various forms of polarization within Congress and expanded upon the ideas from Neal 2020. We have provided evidence that in the nearly 10 additional years after the end of Neal’s analysis, polarization trends continue to rise, nearing close to 100% in some cases of positive within group ties and negative between group ties. When looking at co-voting patterns in a similar fashion, we can see rising weak and strong polarization in Congress as well. Our regression models show some evidence of more central sponsors being able to get more support from members of opposing parties, but the results are not as strong and further analysis and data is needed. As polarization continues to rise, additional research is needed to understand the underlying reasons that drive our society and government to this divided landscape.

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