RESEARCH

A Network Analysis on Partisanship in Congressional Rollcall Votes

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Abstract

In this paper, we examine the widening partisan divide in the United States Congress under the framework of network science. By using the cosine similarity of members' positions in rollcall votes, we are able to assign a polarity and magnitude to the similarity of each member of Congress and relate this to their parties. We show that there is an increasing trend in partisanship in the United States Congress over the past 72 years that could be driven by both Presidential leadership and outside political and economic events. By looking at the intra-party and inter-party similarity scores of the different networks, we form a picture of the solidarity of each party and the cooperation across party lines throughout the duration of the data. Finally, we show that outliers detected using this method match up with widely accepted outliers within their own parties such as Blue Dog Democrats and centrist Republicans.

Keywords: network science, complex systems, partisanship, political party, voting, rollcall, united states congress, cosine similarity

Introduction

In December of 2019, a motion for an impeachment inquiry of Donald Trump was passed on the grounds of abuse of power and obstruction of Congress. It is notable that the votes in the House of Representatives were split on party lines with nearly all Democrats and no Republican in favor of impeaching President Trump. However, it still resulted to non-conviction after going through the majority-Republican Senate. This outcome once again highlighted the increasingly partisan political environment of the U.S. Congress. The impeachment of President Trump in the House of Representatives was considered a symbolic win as most political news websites of the time considered the United States Senate a Republican stronghold and thus predicted that the impeachment will not pass. In an ideal political environment, members of Congress should be able to vote on their own accords and not simply follow political party lines.

Related Work

In recent years, the U.S. government has been observed to grow more partisan than ever [1]. This behavior could lead to increasing animosity between members of opposite parties, less collaboration on national issues, and a lack of independence in voting. Partisanship can lead to policy battles and inability to resolve motions [2]. This study attempts to look at the way Republican and Democratic members vote on motions passed in the congress and how deeply they differ over time. Voting patterns over time will help analysts infer the effect of leadership / administration and political events on congress decisions through the years. A network science approach will help uncover the presence of polarity or cooperation of political leaders across party lines. This study will also look at how party affiliations of congress members shape their voting record. Data on the members' roll call vote decisions in agreement or disagreement to a motion is used to create networks of House Representatives and Senators for every Congress. The analysis aims to show the decline of members who agree with members of the opposite party and how this reflects changes in partisanship over the past 72 years.

Network science has been widely used in understanding complex systems such as social networks [3]. It has been effective in uncovering

structure in the U.S. congress as done by Andris, et al.[4] who defined an undirected network of pair-wise relationships between house representatives. They measured the extent to which representatives form ideological relationships with representatives from the other party and quantified the level of collaboration using a mutual agreement rate. They counted the number of times a pair voted the same way in a specific congress and used that frequency as the edge weight. Their study also shows that despite the increasing partisanship, a few representatives continue to cooperate across party lines. They also looked at the number of bills introduced and noticed a correlation between the rise of partisanship with the failure to pass a legislation. According to Ornstein, et al.[5], this non-cooperation in the House of Representatives showed a negative effect in efficiency and productivity. Lan, et al.[6] used network relationships between house representatives to predict their voting behavior based on others' voting behavior. They used historical voting data and the congressmen's social network relationships as features for their model. They were also able to identify a subgroup who are likely to vote differently from their party to whom they focused the behavior prediction on. Another analysis on the bills-voting dynamics of congressmen was done by Colliri & Zhao [7] in Brazil through temporal networks. Each voting session is mapped into static networks, generated by an accumulated weight matrix, where each node represents a congressman and each connection represents a similiarity of vote between a pair. Their work was able to capture political changes in Brazil during the period of time under consideration.

This paper will discuss a new approach in quantifying the polarity and magnitude of agreement or partisanship in Congress using a network science framework, followed by an interpretation of the findings in terms of overall trend in the political behavior and its implications in the U.S. government.

Data and Methodology

Dataset

The dataset collected was collected from the UCLA Department of Political Science's Voteview initiative that tracks every Congressional rollcall vote in the history of the United States Congress. In the United States Congress, there are 4 different types of votes that may be called upon[10] : voice vote, division vote, yea and nay vote, and a recorded vote. Voice votes and division votes are not recorded as these pertain to votes wherein a member of the Congress must either verbally voice out yea or nay (for voice votes), or stand when their position is called (division votes). Recorded votes are simply rollcall votes that require at least one-fifth of a quorum to agree to the proposition of a vote, whereas a yea or nay vote requires only one-fifth of those present during that session to agree to the calling of a vote. Both yea and nay and recorded votes comprise the dataset of rollcall votes from UCLA's Voteview initiative.

The dataset contains information on every Congress in the United States history pertaining to: members of both chambers of Congress for every Congress, political affiliations of each member of Congress, a record of every rollcall vote called within the Congress, and the vote that was recorded for every member with regard to a rollcall vote.

Methodology

In this study, we examine the partisanship of each chamber of the United States Congress across 72 years. This encompasses the 80th Congress (1979-1949) up until the most recently concluded 115th Congress (2017-2019). We look at each chamber of Congress, House and Senate, as well as the two main political parties in the United States, the Democratic Party and the Republican Party. In order to determine the similarities and differences in voting patterns, we construct a network for each chamber of Congress. This network has nodes which represent each member of senate or house and edges that are representative of how similarly each member of congress votes with another member. As such, the network created is a fully connected network wherein an edge exists between all possible pairs of members of congress. **Figure 1** shows a sample network representation of the 115th House of Representatives, with blue nodes representing Democrats, red nodes representing Republicans, and gray nodes representing other parties.

To determine the edge weights, we look at the cosine similarity of the voting pattern of each member of congress against another member. The simple counting method such as the one implemented by Lan, et al.[6] where they get the total number of agreements of a pair of congress members and divide this by the total number of rollcall votes of that given congress can give a good approximation of how agreeable two members of congress are, however,

this does not necessarily give an indication of the directionality of the overall agreement between two members of congress. Through the use of cosine similarity, we are able to encode the directionality, whether positive or negative, of the level of agreement of the voting patterns of all pairs of members of each chamber of congress. The formula for cosine similarity as shown below:

$$cos(\theta) = \frac{A \cdot B}{||B||x||A||}$$

gives us a range of values from [-1,1] that tells us how similar the voting records between two members of congress are.

To construct our networks, we create an adjacency matrix *A,* where each *Aij* contains the cosine similarity score between members of congress *i* and *j.* We start with a table of rollcall votes where each row corresponds to a member of a particular chamber of Congress (House or Senate), each column represents a rollcall vote, and each cell represents the vote of a member of congress with respect to a rollcall vote. Votes that are registered as "Yea" or "announced Yea" are marked as 1, votes that are "Nay" or "announced Nay" are marked as -1, and absences and abstained votes are converted to *NaNs.* The following pseudocode was applied to generate the adjacency matrix *A* from the original data:

```
FOR every member i,
        FOR every member j,
                IF i==j,
                        Aij = 1
                ELSE,
                        Aij = cosine similarity of
                        all non-NaN votes
                        between i and j
        ENDIF
ENDFOR
```

This is then fed to the python package *networkx* to create a fully-connected undirected network representation of the voting patterns of a given Congress with members as nodes and edges as the cosine similarity. We repeat this for each chamber of Congress for each Congress from the 80th-115th Congress of the United States.

Results

Intra-Party Similarity

In determining the trend of partisanship in the United States Congress leading up to the current administration of President Donald J. Trump, we can take a look at the average degree of each congress network from the 80th to the 115th congress. By looking at the average degree of each network, we are effectively looking at the how similar the voting patterns of each party, Democratic and Republican, in each chamber of Congress, House and Senate, across time. This represents what we call the "intra-party similarity" score; this tells us how similar persons in the same political party vote with regard to rollcalls. In **Figure 2 and 3**, we can see that there is a general uptrend in the average degree, and therefore the average similarity of voting patterns, over time in Congress. This upward trend can be observed in the long run, with spikes of increased and decreased average degree in certain congresses. One of the largest drops in average degree can be seen in the 114th Congress. This congress covers the years 2014-2016, effectively the last years of the Obama administration. The House of Representatives in particular had significantly lower voting similarity scores across both political parties which could indicate more bipartisan initiatives during the given Congress. A similar trend can be observed among Republicans during the term of President Obama covering the 110th to 114th Congress in the Senate. The average degree of similarity among senators in the Republican party during this time was varied, perhaps indicating that Republican senators were voting across party lines more often during this period. As seen in **Figure 2,** this intra-party similarity score sharply increases to its highest score historically, during the term of President Trump. It should be noted that President Obama was a Democrat while President Trump is a staunch Republican.

Inter-Party Similarity / Cooperation Score

Aside from the intra-party score, we can also look at the "inter-party" similarity score which represents a sort of cooperation score among different parties. This is done by taking the average degree of all edges that connect a Republican node to a Democratic node in both chambers of congress. The cooperation or intra-party similarity score then represents the level of agreement or bipartisan voting that exists in a particular chamber of congress. In contrast to the

increasing trend of intra-party similarity scores that was observed in **Figures 2 and 3** in **Figure 4** we can observe a downward trend between cooperation or inter-party similarity scores among both chambers of congress. This is expected as a higher intra-party similarity score (partisan voting) necessarily leads to lower inter-party similarity score (bipartisan voting). We can see some increases in the cooperation scores that are highlighted in red in **Figure 4** which correspond to the 108th Congress, which spanned the years 2003-2005, wherein the administration of President Bush was brought together with the declaration of war in Iraq in March of 2003. Another interesting event during this time was during the 110th-111th Congress, highlighted in gray, which spanned the years 2007-2011 wherein the Obama administration had to grapple with the 2008 global financial recession.

We also look at the change in cooperation score, specifically the direction and magnitude of the change in cooperation score between two congresses. **Figure 5** shows the direction and magnitude of the change in cooperation scores for the Senate and House of Representatives, respectively, over time. We can see that during the 111th-112th Congress, the Senate experienced its second-highest positive change in magnitude of cooperation score, indicating that the Senate chamber voted more in line with their party as compared to the 111th Congress. On the other hand, the House of Representatives experienced the largest negative change in similarity during this period. This indicates that the 112th Congress was vastly more bipartisan than the 111th Congress.

Outliers

Using the network degrees, we can also take a look at the outliers for each chamber of Congress over time. Outliers are defined as being 2 standard deviations away from the mean cosine similarity of a given congress. As the distribution of similarity scores over time is different for each congress, looking at 2 standard deviations away to determine the outliers naturally scales the definition of outliers with respect to the similarity distribution of the given congress. The summary of total outliers can be seen in **Table 1**. Looking at the outliers, we can identify those members of congress that are not fully aligned with their respective political parties. For example, in the 115th Congress, Senator Rand Paul of the Republican party is one of the top outliers; he is also identified by the political website FiveThreeEight as being the Senator who is least supportive of President Trump. On the Democratic Party side, Senator Joe Manchin and Senator Heidi Heitkamp both show up in the list of outliers to the party. These two senators are also known as Blue Dog Democrats, that is a member of the Democratic Party who identify as fiscally conservative, centrist Democrats.

Conclusion

Our analysis shows that partisanship in both the House of Representatives and the Senate has intensified significantly over the past 72 years. Voting behavior of members are more likely influenced by political identity rather than by their distinctive view on the motions passed. The decisions members make could also be influenced by the ideological positions and charisma of their party leaders. The administration's way of leadership and the president's effectiveness at motivating or persuading partisans could be another factor. There are complex interactions that drive decision-making of these congress members and even though our data does not provide clear evidence on the association of these factors to partisanship, their effects are observable. In the context of current affairs, it is possible that members' preferences are highly irreconcilable, and their values are fundamentally different. The consolidation of power within each of the two dominant political parties may also have an effect of the wider ideological split, and thus the increase in partisanship. Issues on the role of government, gender, race, immigration, and culture divide members under party labels – Republicans and Democrats are mostly unified under a set of views on these matters. Historically, Americans have always had differences in opinions but nowadays, it looks like people with the same views are clearly sorted in two different parties as opposed to having mixture of opinions within parties. The observed non-cooperation trend suggests lack of agreement and alignment across party lines, which impairs effective governance, as also shown by multiple news articles [9].

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Figures

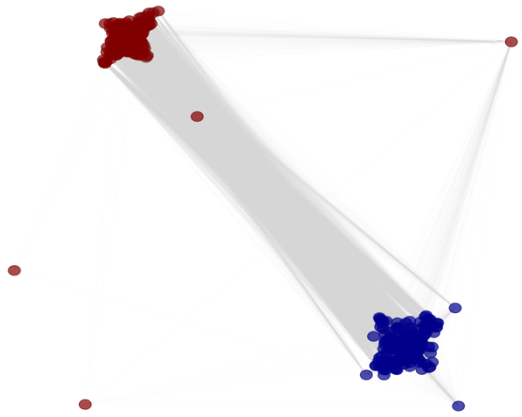

Figure 1: Network of 115th House of Representatives. Network Representation of the 115th House of Representatives with Democrats in blue and Republicans in red. Edge lengths represent the cosine similarity between each member.

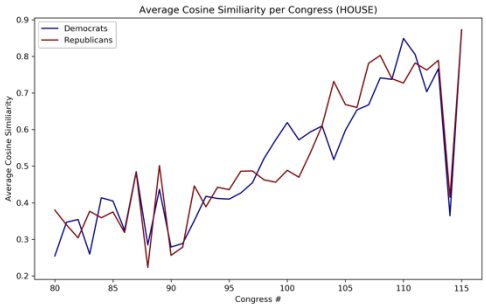

Figure 2: Average Degree (Cosine Similarity) House of Representatives. Average cosine similarity for House of Representatives for Congress 80-115.

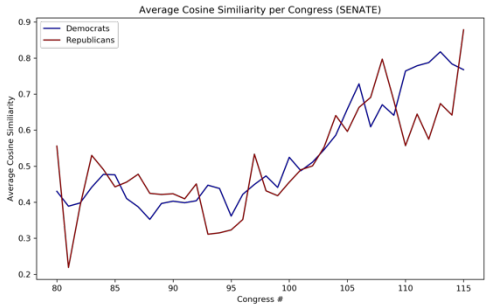

Figure 3: Average Degree (Cosine Similarity) Senate. Average cosine similarity for Senate for Congress 80-115.

Figure 4: Cooperation Score (Inter-Party Similarity) of House of Representatives and Senate. Figure 4 shows the decreasing trend of the cooperation between the Republican and Democratic party from Congress 80-115. The highlight in red shows the period of the Iraq war, while highlight in grey shows the global financial crisis of 2008-2012.

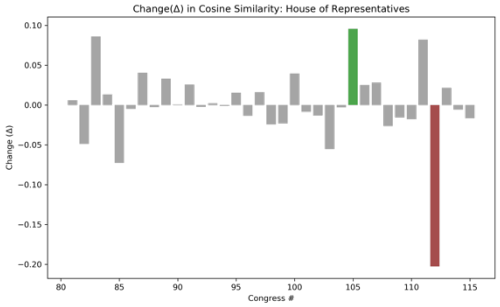

Figure 5: Change in cooperation score (House of Representatives). Figure 5 shows the year-on-year change in cooperation score from Congress 80-115.

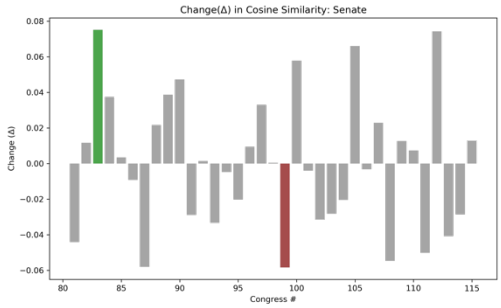

Figure 6: Change in cooperation score (Senate). Figure 5 shows the year-on-year change in cooperation score from Congress 80-115.

Tables

Table 1 Outliers per Congress. Table 1 shows the number of outliers per Congress divided into Republicans and Democrats for each chamber of Congress (House and Senate).

Congress #	Senate Democrats	Senate Republicans	House Democrats	House Republicans
80	2	2	10	19
81	0	4	16	12
82	1	3	16	20
83	0	6	6	14
84	2	2	18	20
85	3	3	15	10
86	4	1	22	13
87	5	2	18	4
88	4	1	5	3
89	4	2	24	6
90	3	2	5	7
91	3	3	6	12
92	4	4	13	11
93	5	2	14	9
94	5	4	16	9
95	3	4	15	9
96	3	3	12	12
97	4	2	10	11
98	3	2	13	11
99	4	4	17	13
100	4	3	12	11
101	3	2	18	8
102	3	2	17	8
103	3	0	15	8
104	3	6	12	11
105	3	4	7	6
106	3	3	9	9
107	3	5	7	9
108	2	4	11	7
109	1	3	12	8
110	3	4	14	12
111	3	4	12	9
112	3	3	12	9
113	3	2	10	6
114	3	3	4	34
115	3	3	7	6