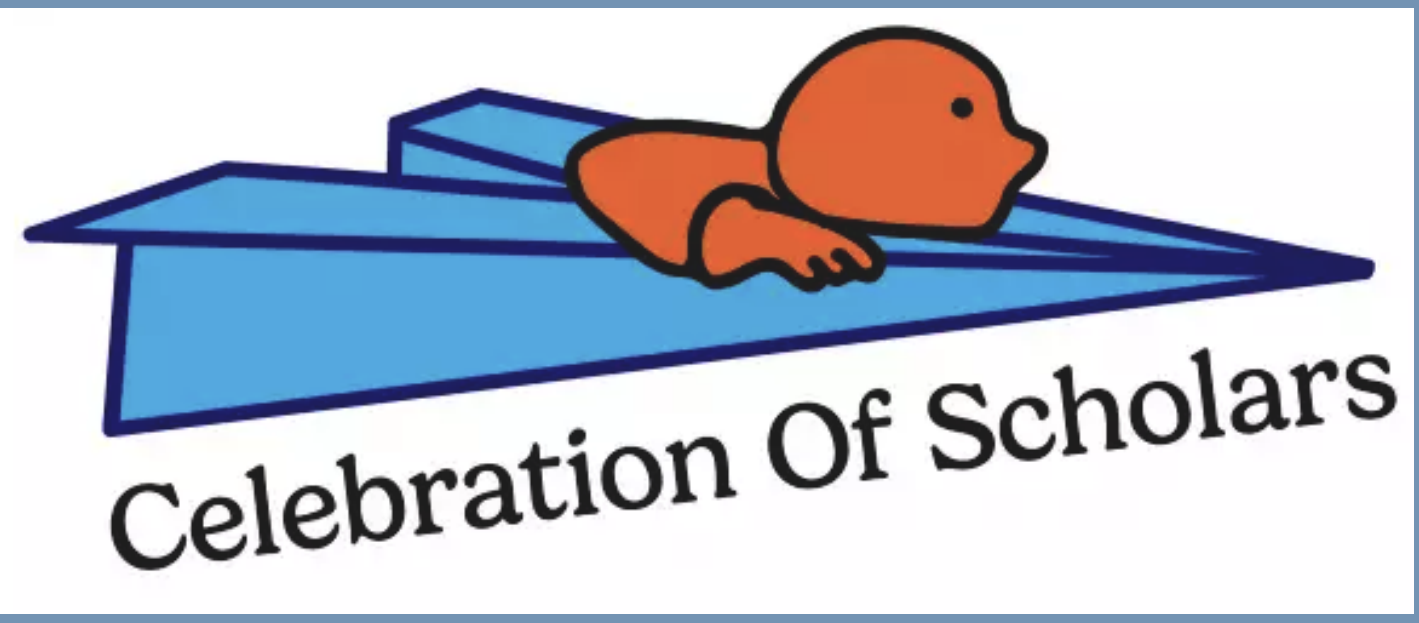




# Patterns in Political Polarization

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## Abstract

The present political climate of the United States suggests that political partisanship has reached an all-time high. How can this be quantified? We investigate polarization in the U.S. Senate with methods previously used to study the U.S. House of Representatives. By measuring agreements within and between members of political parties, we create network structures defined by voting records. These networks display the range of senator behaviors, allowing us to track changes in partisanship on both an individual and a party level. We observe shifts in behavior over decades of voting history, highlighting trends and outlier events. Some of our findings may contradict what you hear on the news! This work was completed as part of the Carthage College Summer Undergraduate Research Experience.

## Cross-Party and Same-Party Vote Agreement Distributions

We measure polarization in the U.S. Senate using voting records. In our data, a senator can vote “yea,” “nay,” “not voting,” or “present” on a roll call vote. We create agreement matrices for the years 1937-2022 containing the counts of vote agreement between pairs of senators.

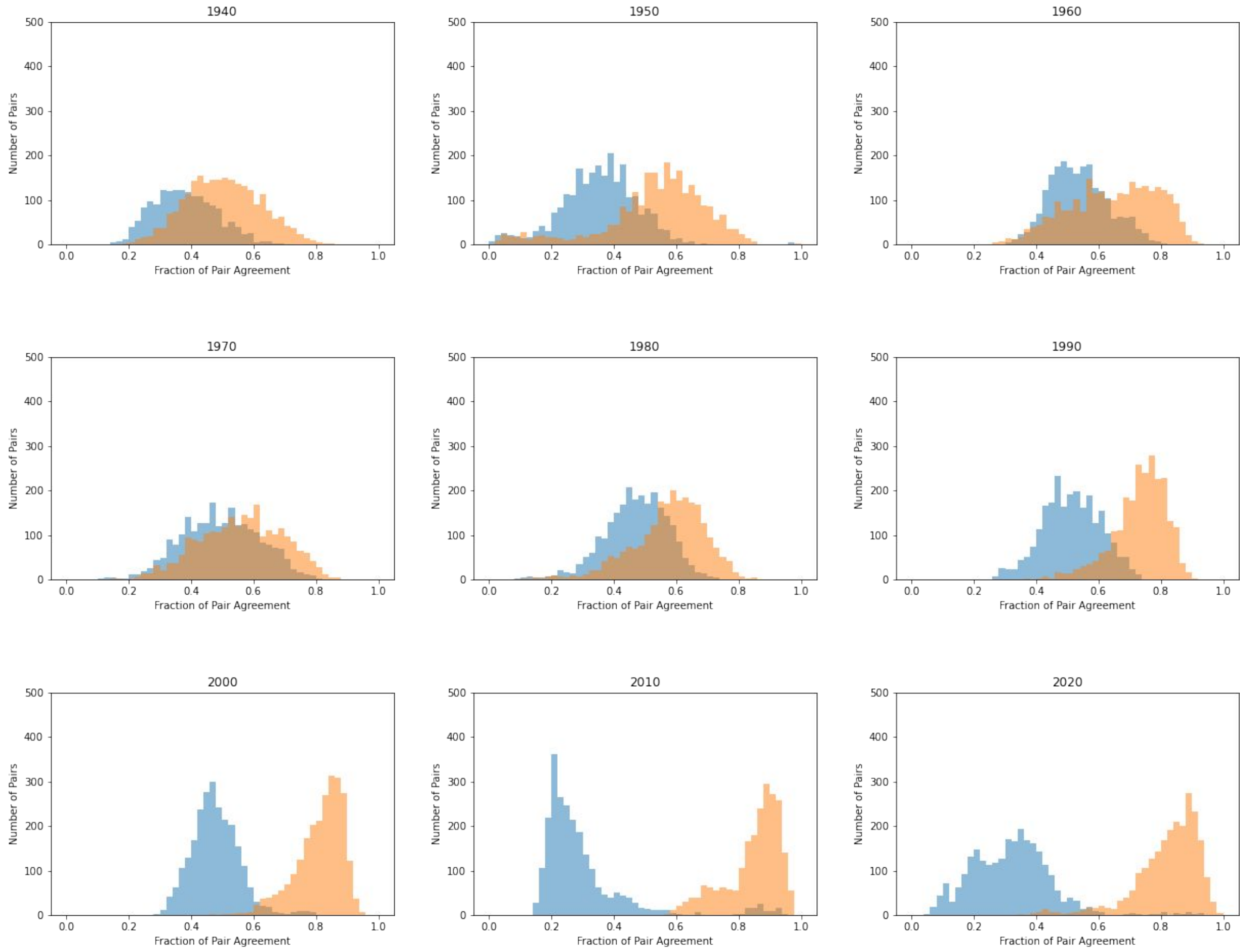


Figure 1. Cross-party pairs of senators (from different political parties, shown in blue) generally do not agree as often as same-party pairs of senators (from the same political party, shown in orange). The overlap between the cross-party pair histograms and the same-party pair histograms appears to be decreasing over time.

We use the histograms to find an agreement fraction threshold for each year. This is the fraction of pair agreement where the same-party histogram overtakes the cross-party histogram. Cross-party pairs of senators above the fraction threshold are classified as cooperators because they are behaving like same-party pairs.

## Senator Vote Agreement Networks

We create voting networks for the years 1937-2022 to visualize senator voting behavior. To reduce noise from senators who do not work together often and focus on the structure of cooperative interactions, we remove pairs of senators who agree less than the fraction threshold.

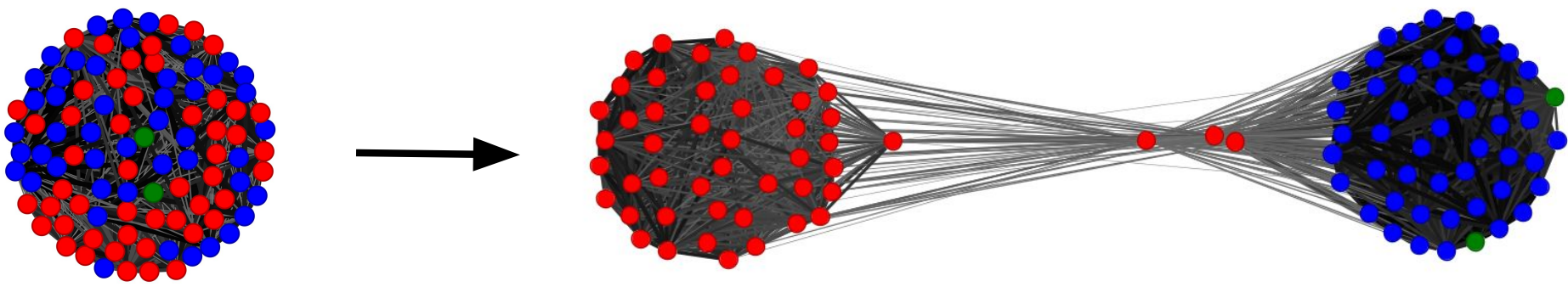


Figure 2. This is the 2022 Senate voting network before and after removing pairs of senators who agreed less than the fraction threshold. This step allows us to highlight the structure of cooperating senators.

Each node in our network represents a senator, with red nodes representing Republicans, blue nodes representing Democrats, and green nodes representing Independents. Edges connect senators who agreed with each other, with darker, thicker, and shorter edges between two nodes indicating higher vote agreement and lighter, thinner, and longer edges between two nodes indicating lower vote agreement.

## Example Networks: Trends over time

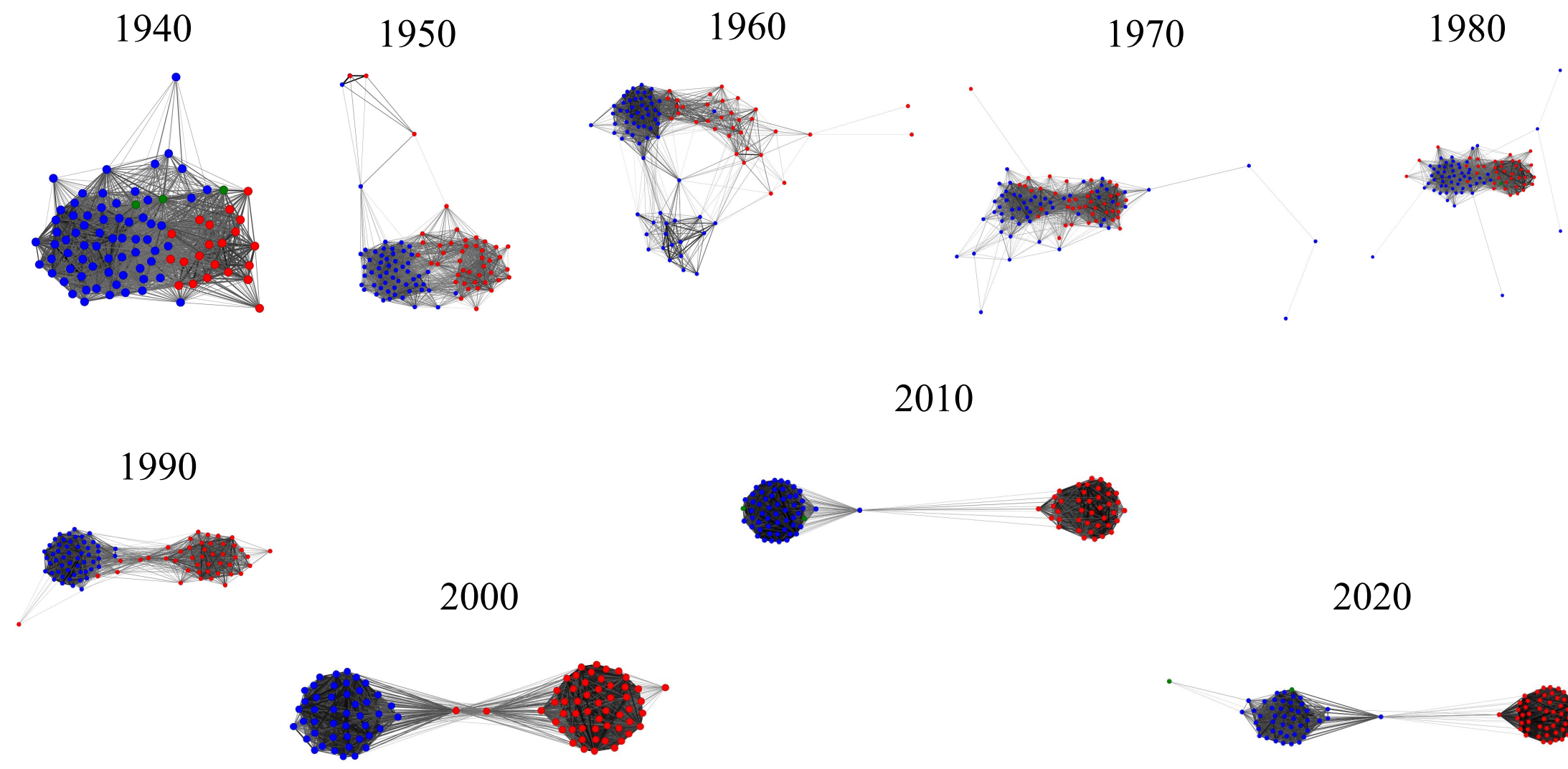


Figure 3. These networks track the structure of how senators vote with each other.

We use the vote agreement networks to look for patterns in voting behavior. Over time, the Democratic and Republican parties appear to split into two distinct groups, with fewer senators agreeing across parties.

## Cooperator Pairs and Assortativity

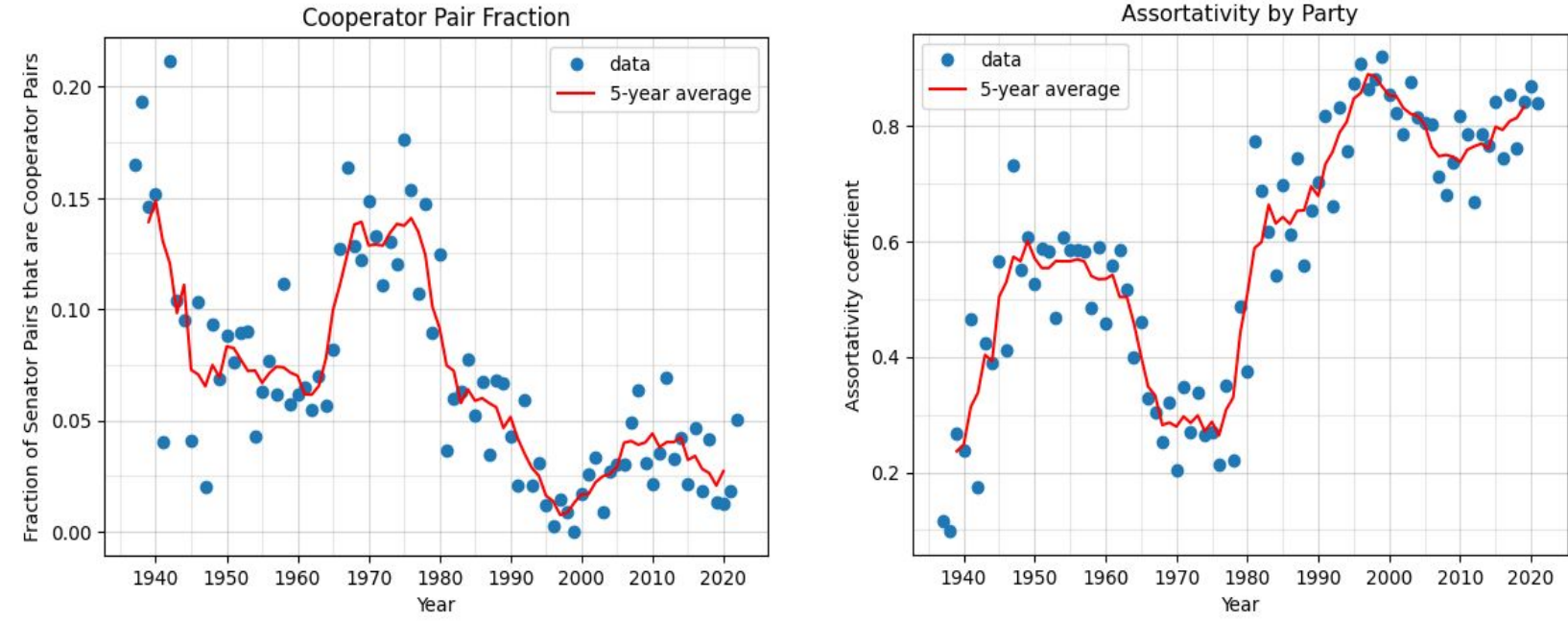


Figure 4. Cooperator Pairs and Assortativity over Time

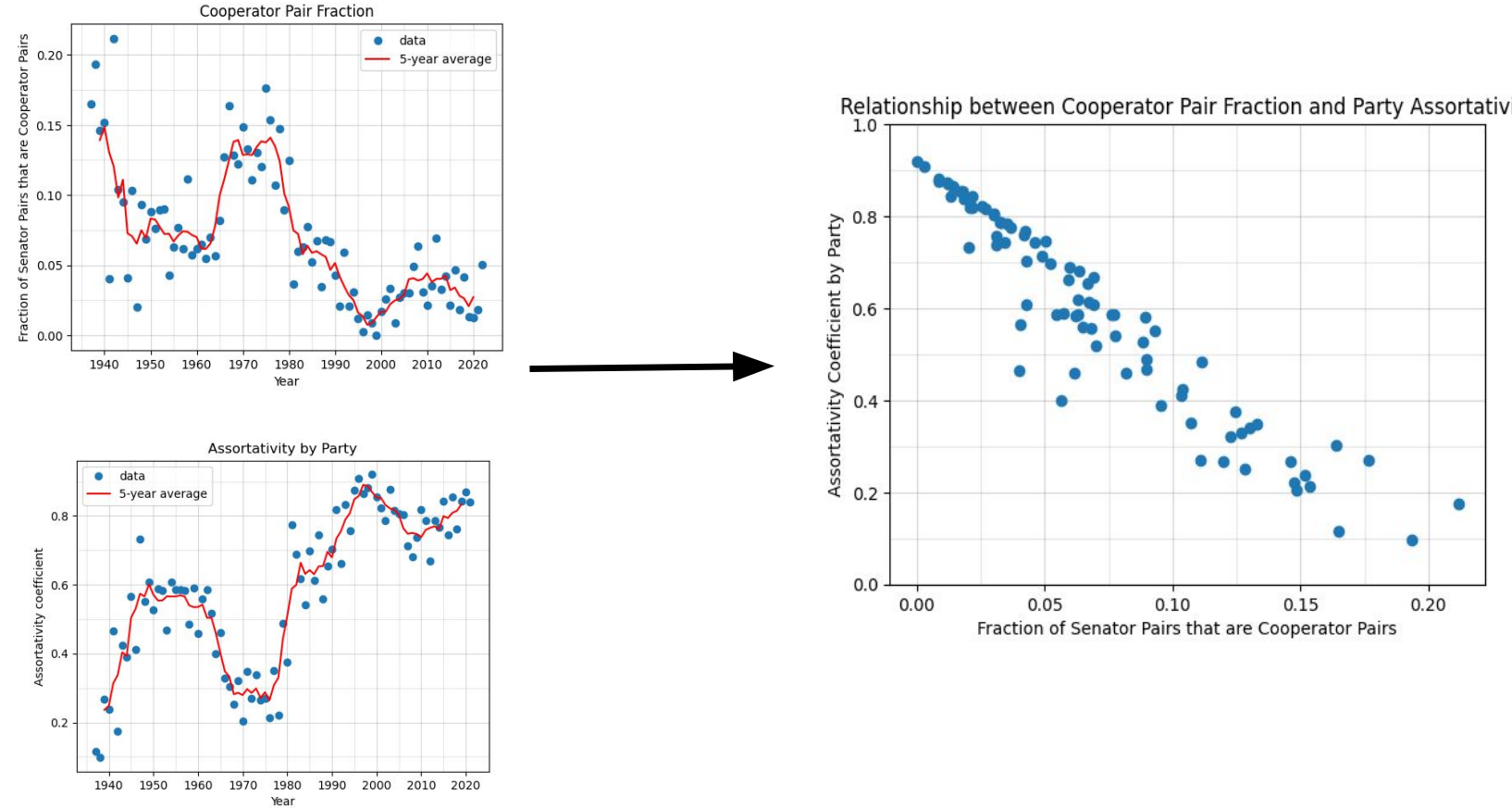


Figure 5. Correlation between Cooperator Pairs and Assortativity

Figure 6. There is a negative correlation between the number of cooperator pairs and assortativity.

After we plotted the assortativity coefficient over time, we noticed how it appeared to be a reflection of the cooperator pair graph! We wanted to see if we could quantify this observation. To accomplish this, we plotted the correlation between the cooperator pair fraction and the assortativity coefficient. As the cooperator pair fraction increases, the assortativity decreases, which agrees with our visual observation

## References

Andris, C., Lee, D., Hamilton, M. J., Martino, M., Gunning, C. E., Selden, J. A. (2015). "The Rise of Partisanship and Super-Cooperators in the U.S. House of Representatives." *PLOS ONE* 10(4): e0123507. <https://doi.org/10.1371/journal.pone.0123507>.  
Morris, N. (2018) "Has Polarization in the Senate Grown?" *Senior Thesis*  
UCLA Political Science VoteView. (2023). "Voteview.com" Retrieved from <https://voteview.com/>

## Network Analysis: Betweenness

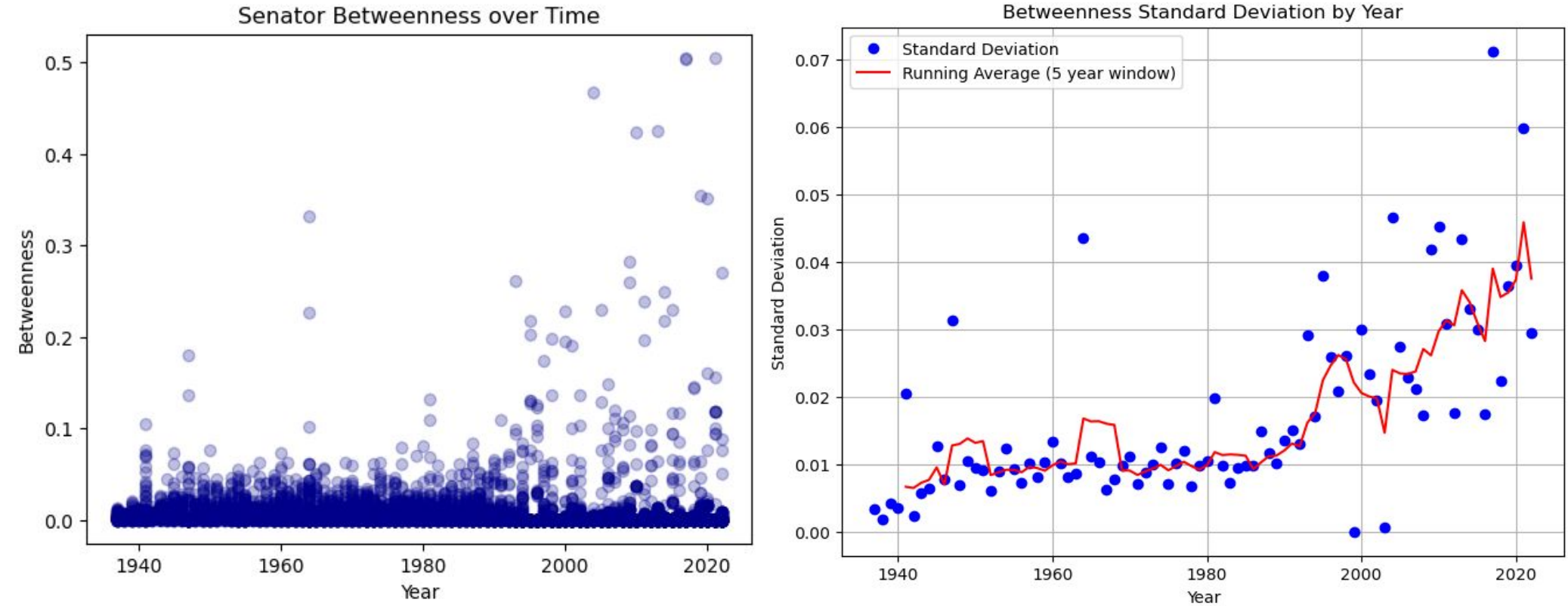


Figure 7. (Left)Distribution of betweenness values.(Left)Standard deviation of betweenness values.

Betweenness measures the extent to which a vertex lies on paths between other vertices. The higher the betweenness, the more the vertex lies in the way of other vertices. In the case of our study, the vertices are senators, with the edges being how often they voted together. We created the standard deviation plot on the right to quantify the distribution of senators' betweenness over time. Early on, there are few senators with very high betweenness. Yet, as we move further in our years of study, the number of senators with higher betweenness increases.

## Trends Over Time: Polarizing Votes

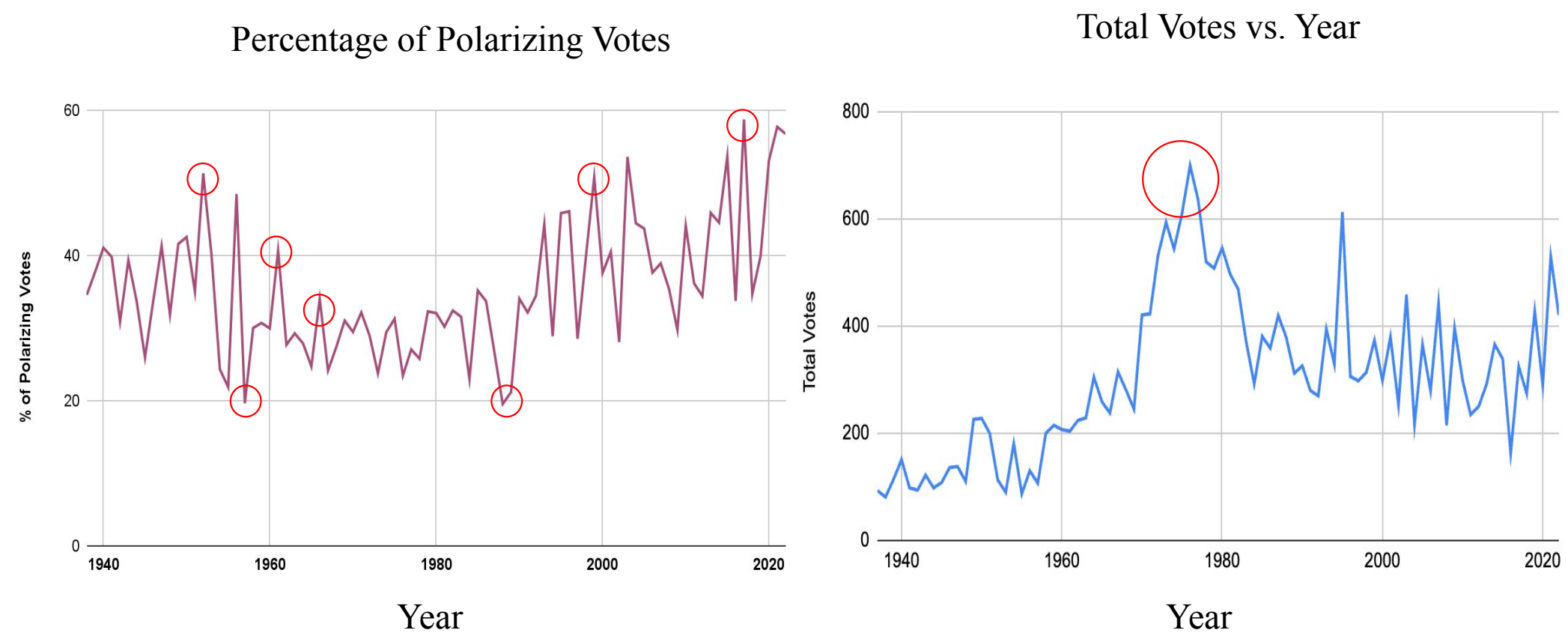


Figure 8. (Left)Line Graph of the percentage of polarizing votes over time. (Right)Line graph of Total, bills over time.

We analyzed the topics that held the highest number of polarizing bills in a given year. Polarizing bills/amendments/motions are ones that received between 40-60 percent yea votes. We intuitively chose this range because whatever was being voted on, passed or failed by a slim majority, meaning there was little to no agreement. The figure on the left represents this study as we looked at the ten most voted on topics in 1964 compared to 2022. In the figure on the right, the percentage of polarizing roll call votes does not display an immediate trend, but we are hoping to analyze the years with high peaks or valleys.

## Discussion

Our analysis shows evidence of increasing separation in the Senate over the past eighty-six years, mirroring the public's opinion of United States' politics. We can see this elevated partisanship in an increased dissimilarity between same-party and cross-party senators and a decrease in cooperation between cross-party senators.

We see the growing disconnect between the Democrats and Republicans in our network visualizations. An intermingled group of senators voting together is visible in the earliest data, after which the beginnings of partisanship grow in the 1980s and increase thereafter. This separation continues as we move from the 20th century into the 21st century, with 2022 having almost two distinct groups with little connection.

As we continue our research, we will explore alternative measures of polarization using tools from network science, statistics, and political science. Preliminary results have shown further evidence of separation in the United States Senate.